NEW

HISTORY *of* MEDICINE

Discover the gruesome practices that led to medical progress

DA VINCI'S DISSECTIONS AND INFAMOUS ANATOMICAL ART

FROM THE MAKERS OF ALL ABOUT HISTORY

Digital Edition

SECOND EDITION

EVOLUTION OF MEDICINE • PIONEERS • KEY DISCOVERIES

WELCOME TO

HISTORY of MEDICINE

Diagnosis, treatment and prevention of disease or illnesses are all things that have been practised throughout the different phases of human history. It is safe to say that we as humans would certainly not exist in the capacity that we do now without the medical advancements that we have made. The History of Medicine will look at the best and brightest revolutionaries of the medical field, from Hippocrates and his development of the Hippocratic Oath, to Alexander Fleming and his invention of penicillin, the 'wonder drug'. It will also detail the greatest medical inventions and discoveries so far, such as the thermometer, microscope, X-ray machine, anaesthetic, aspirin and more. Finally, it will show just how much of an impact medicine has had on our lives by exploring the evolution of medical practices.

FUTURE

HISTORY *of* MEDICINE

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Cover images
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Printed by William Gibbons, 26 Planetary Road,
Willenhall, West Midlands, WV13 3XT

Distributed by Marketforce, 5 Churchill Place, Canary Wharf, London, E14 5HU
www.marketforce.co.uk Tel: 0203 787 9001

History of Medicine Second Edition
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Future plc is a public
company quoted on the
London Stock Exchange
(symbol: FUTR)
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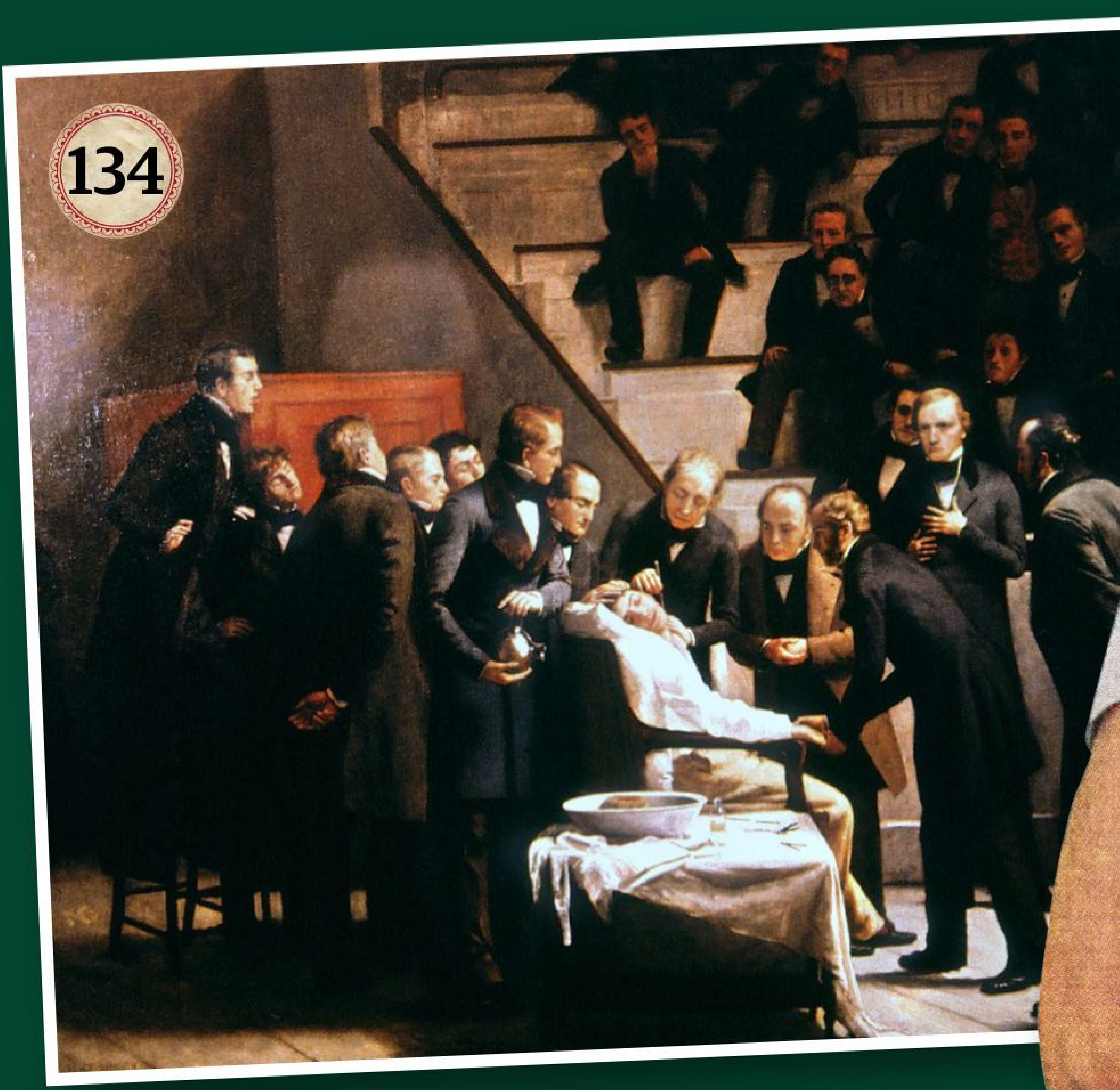

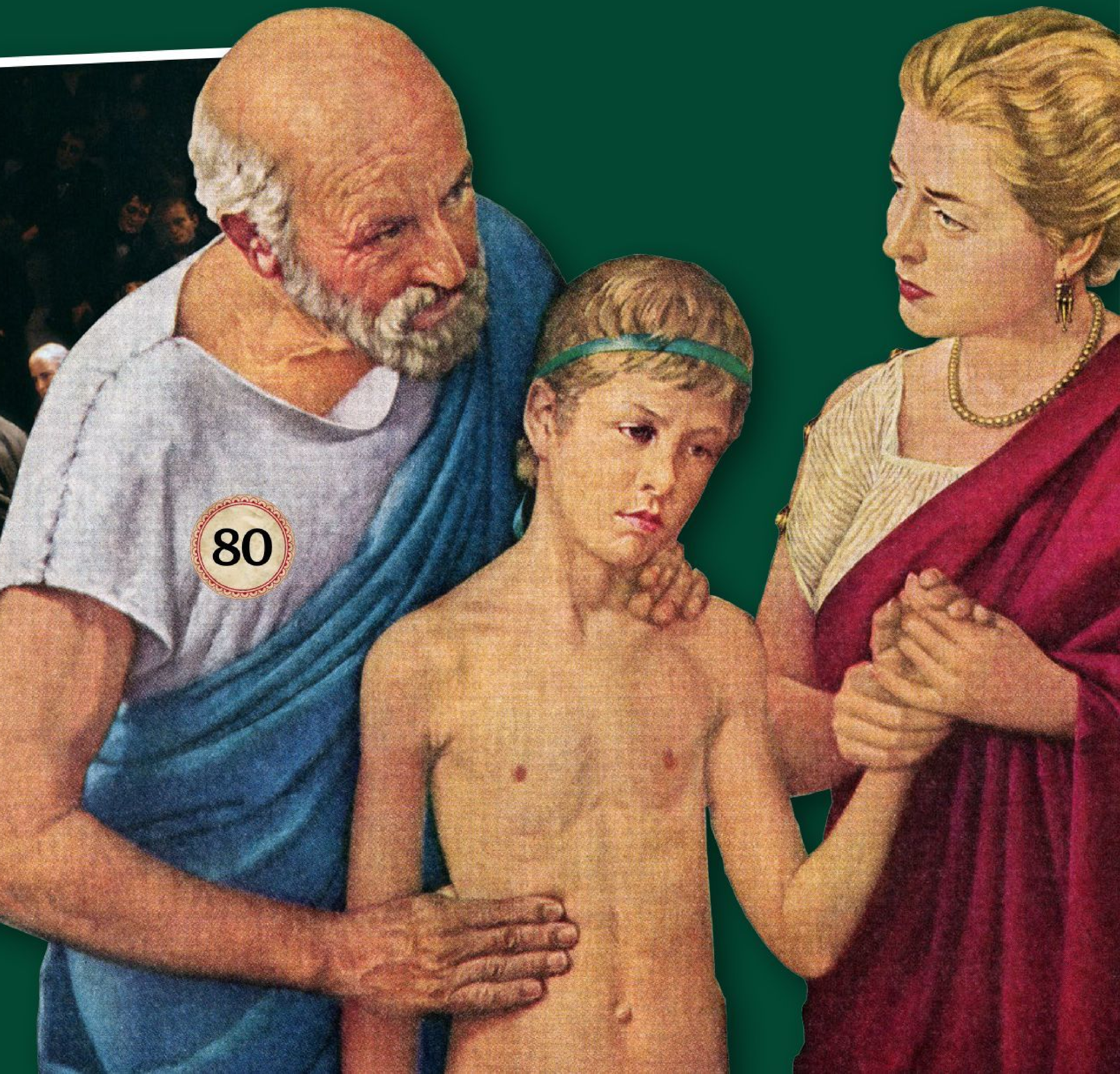

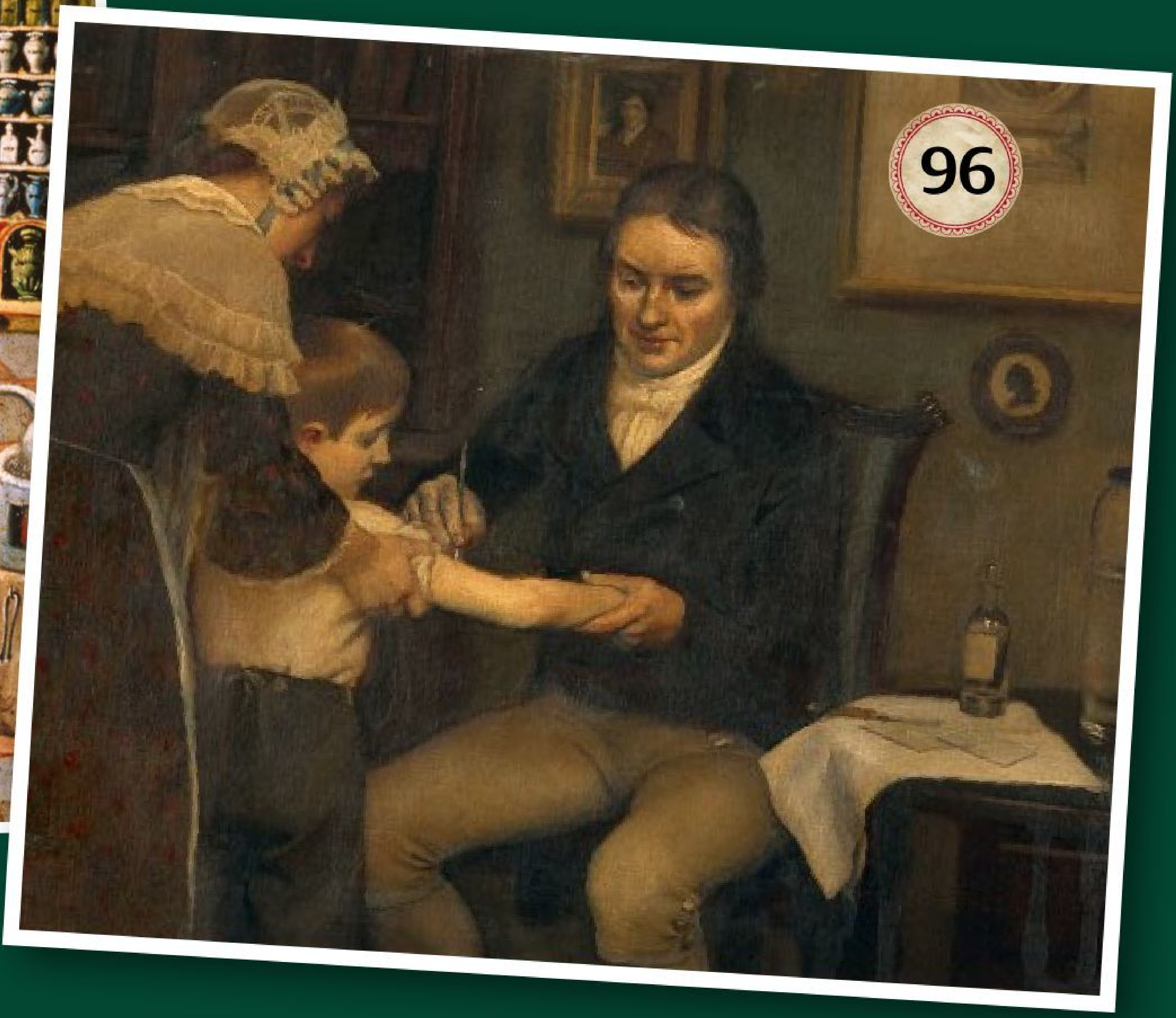

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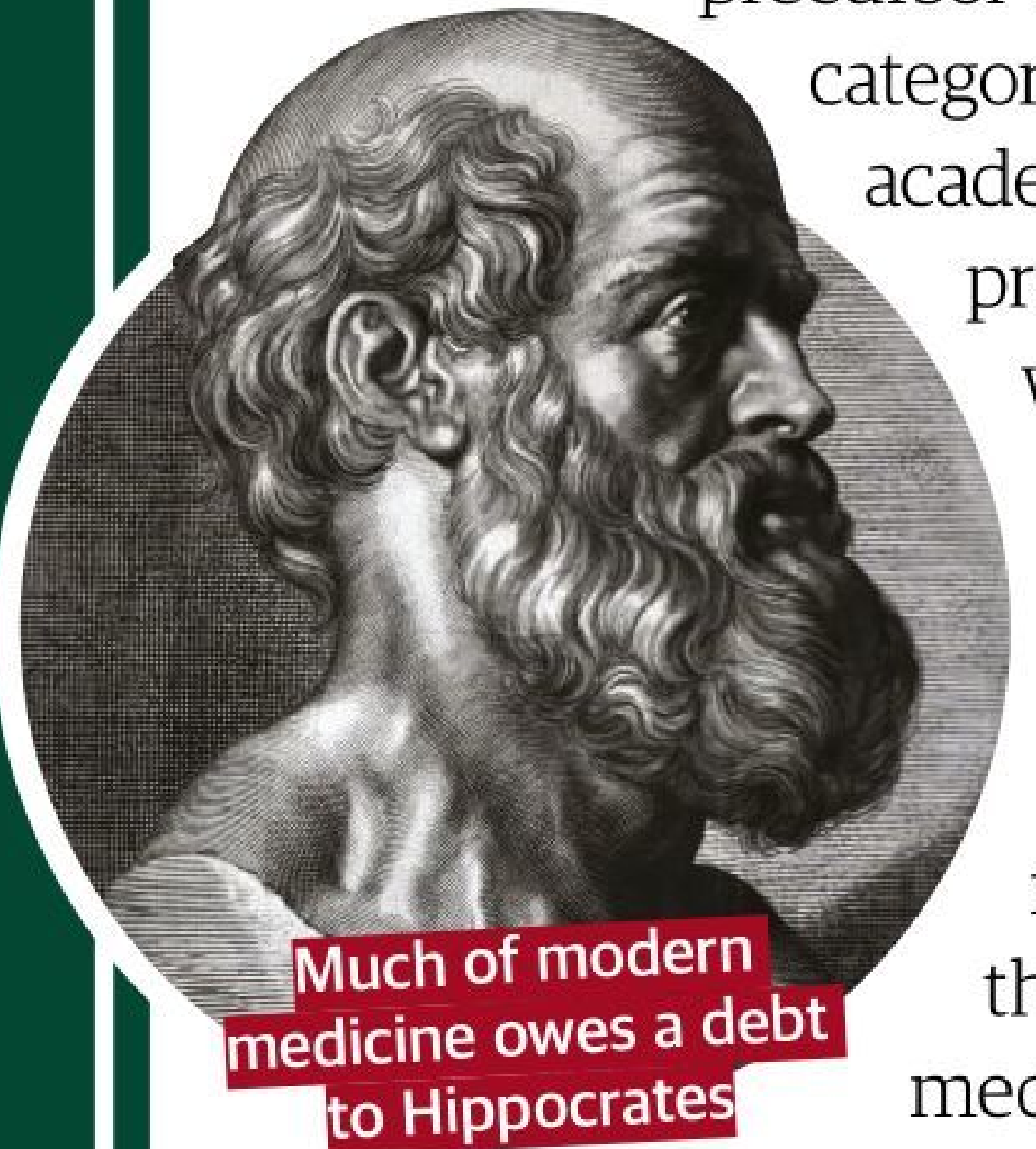
MEDICINE ACROSS HISTORY

FATHER OF MEDICINE

GREECE 460 BCE

Hippocrates, the father of Greek and arguably the entirety of Western medicine, is probably the most important person in the whole history of the field. Not only did Hippocrates institutionalise the scientific study of medicine and define what a doctor's role was – as well as giving us the Hippocratic Oath that all doctors are sworn to abide to – he also made many discoveries, such as a precursor to aspirin, and played a huge part in first categorising illnesses. He wasn't just a hands-off academic, either, with records showing that he practised what he preached, becoming the world's first documented chest surgeon. Interestingly, while Hippocrates' medical teaching was widely accepted in Ancient Greece, after his death, medicine as a field largely stalled, with old practises recommencing. It was arguably not until the time of Galen over 500 years later that medicine began to advance once again.


Much of modern medicine owes a debt to Hippocrates

Hippocrates with Democritus, whom he was asked to cure of a supposed madness

Galen is born

ROME 130 CE

Prominent Roman physician and philosopher Galen is born. He proceeds to become the world's foremost medical authority, being the personal physician to a number of Roman emperors.

Galen treated a number of Roman emperors

Medicine timeline

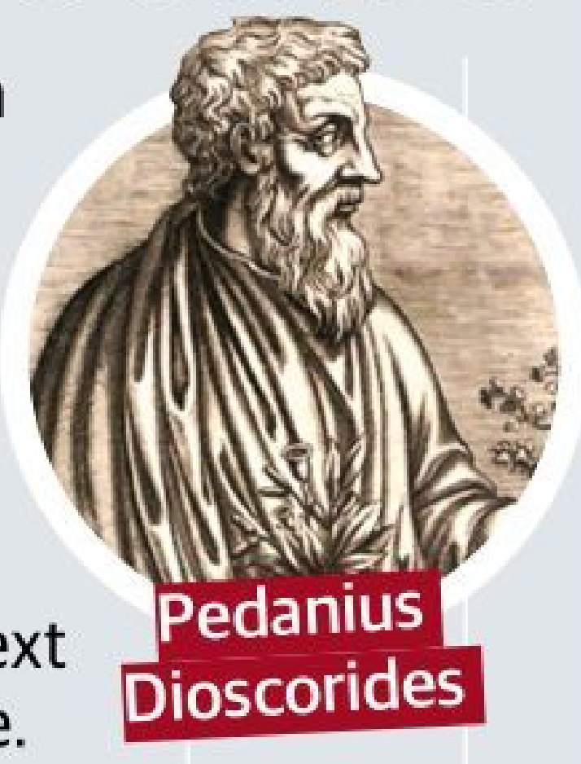
Imhotep diagnoses
The famous Egyptian architect and priest diagnoses over 200 ailments and describes medical treatments for them all. **c.2600 BCE**

Pythagoras

Alcmaeon of Croton
Alcmaeon of Croton, a pupil of the famous Pythagoras, identifies Eustachian tubes and advocates the use of dissection. **c.500 BCE**

Eat well
Famous Greek physician Diocles of Carystus produces the first systematic textbook on animal anatomy and pushes the importance of diet and nutrition. **c.300 BCE**

Materia medica
Greek physician Pedanius Dioscorides completes his great work, *De Materia Medica*, a comprehensive text book on medicine. **c.50-70 CE**


Pedanius Dioscorides

Smallpox identified
Persian polymath Rhazes identifies the deadly bacteria smallpox for the first time, differentiating it from measles. **910 CE**

Rhazes

The Book of Healing
Renowned Persian physician Avicenna writes *The Book of Healing* and then, later, *The Canon of Medicine*, two authoritative medical textbooks. **1027**

Avicenna

Bacon is all eyes
English philosopher and scientist Roger Bacon conducts pioneering research into the anatomy of the human eye, creating a crude precursor to modern glasses. **1249**

Andreas Vesalius
Brabantian anatomist Andreas Vesalius publishes his great medical work entitled *On the Fabric of the Human Body.* **1543**

Blood transfusions
English architect Sir Christopher Wren was one of the first people in history to experiment with the idea of blood transfusions. **1657**

Sir Christopher Wren

Blood cells
Nicknamed the 'Father of Microbiology', Antonie van Leeuwenhoek discovers blood cells for the first time. **1673**

Antonie van Leeuwenhoek

Smallpox in Venice
Venetian physician Giacomo Pylarini gives the first recorded smallpox inoculation to the children of the English ambassador to Constantinople. **1701**

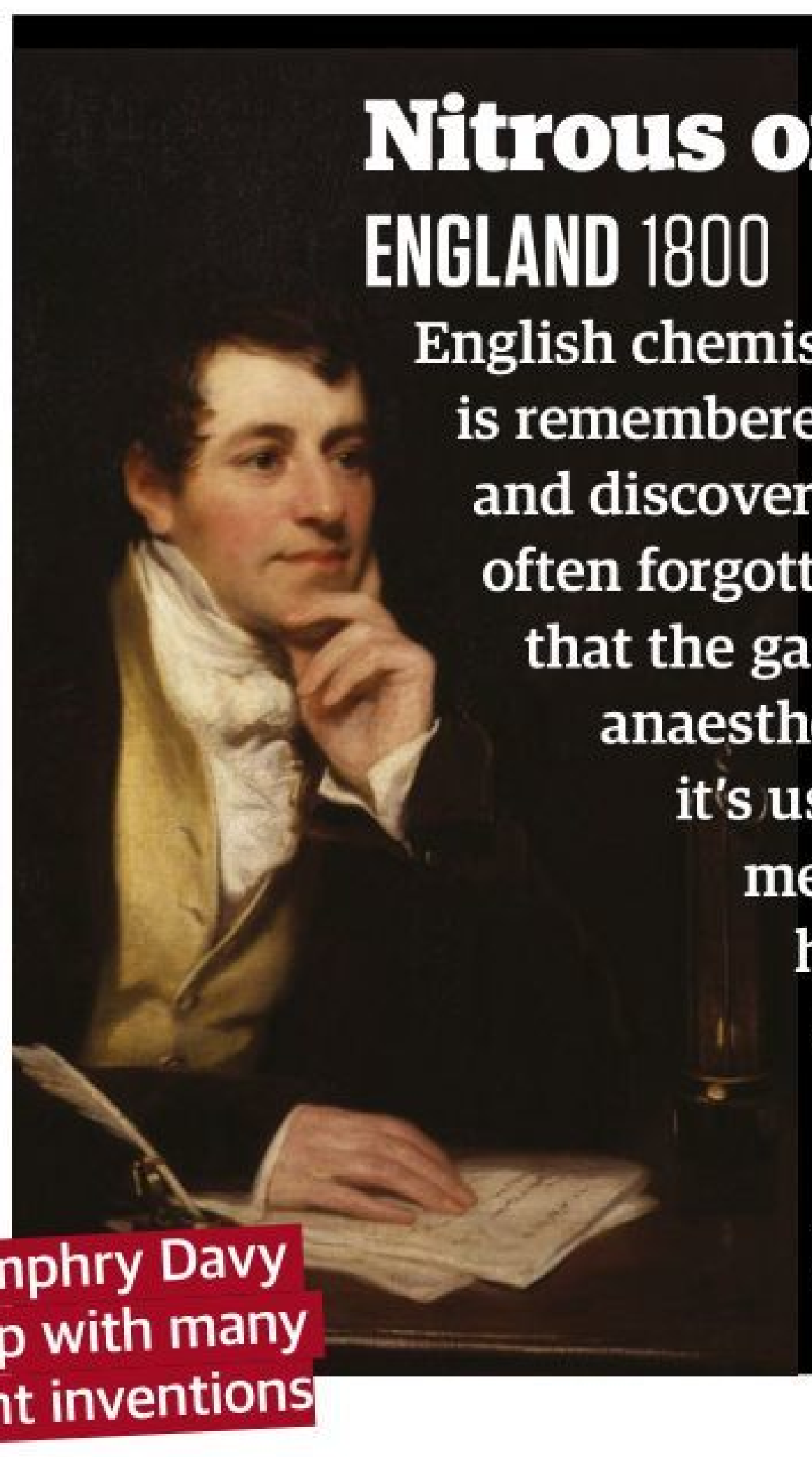
Vaccine invented
English physician Edward Jenner develops the process of vaccination for smallpox, using cowpox to prevent the deadly disease. **1796**

3000 BCE | 500 BCE | 400 BCE | 300 BCE | 0 | 100 | 200 | 1000 | 1200 | 1500 | 1550 | 1600 | 1650 | 1700 | 1750 | 1800 | 1820 | 1840

Nitrous oxide utilised

ENGLAND 1800

English chemist Sir Humphry Davy is remembered for many inventions and discoveries but one that is often forgotten is his observation that the gas nitrous oxide has anaesthetic properties. Today it's used in a variety of medical procedures, however Davy did not realise its potential and it was only put to full use after his death.


Sir Humphry Davy came up with many different inventions

Bubonic plague combated

RUSSIA 1897

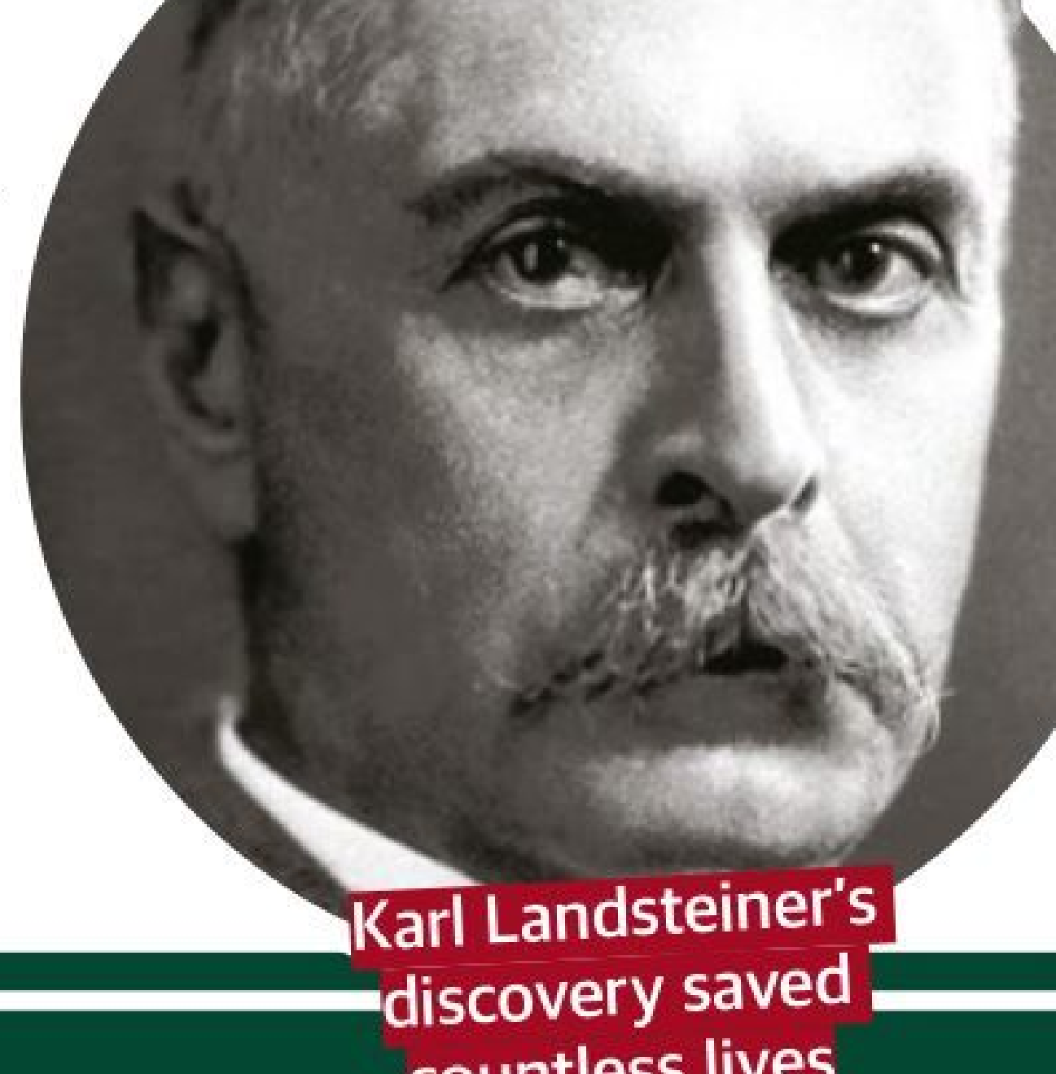
Of all the terrible diseases it was possible to catch, one of the worst was the bubonic plague, with hundreds of thousands of people throughout history dying in great pain and with awful deformity. That all changed when Russian bacteriologist Waldemar Haffkine developed a vaccine against the deadly disease and, after human trials – the first of which was on himself – started to distribute the vaccine.

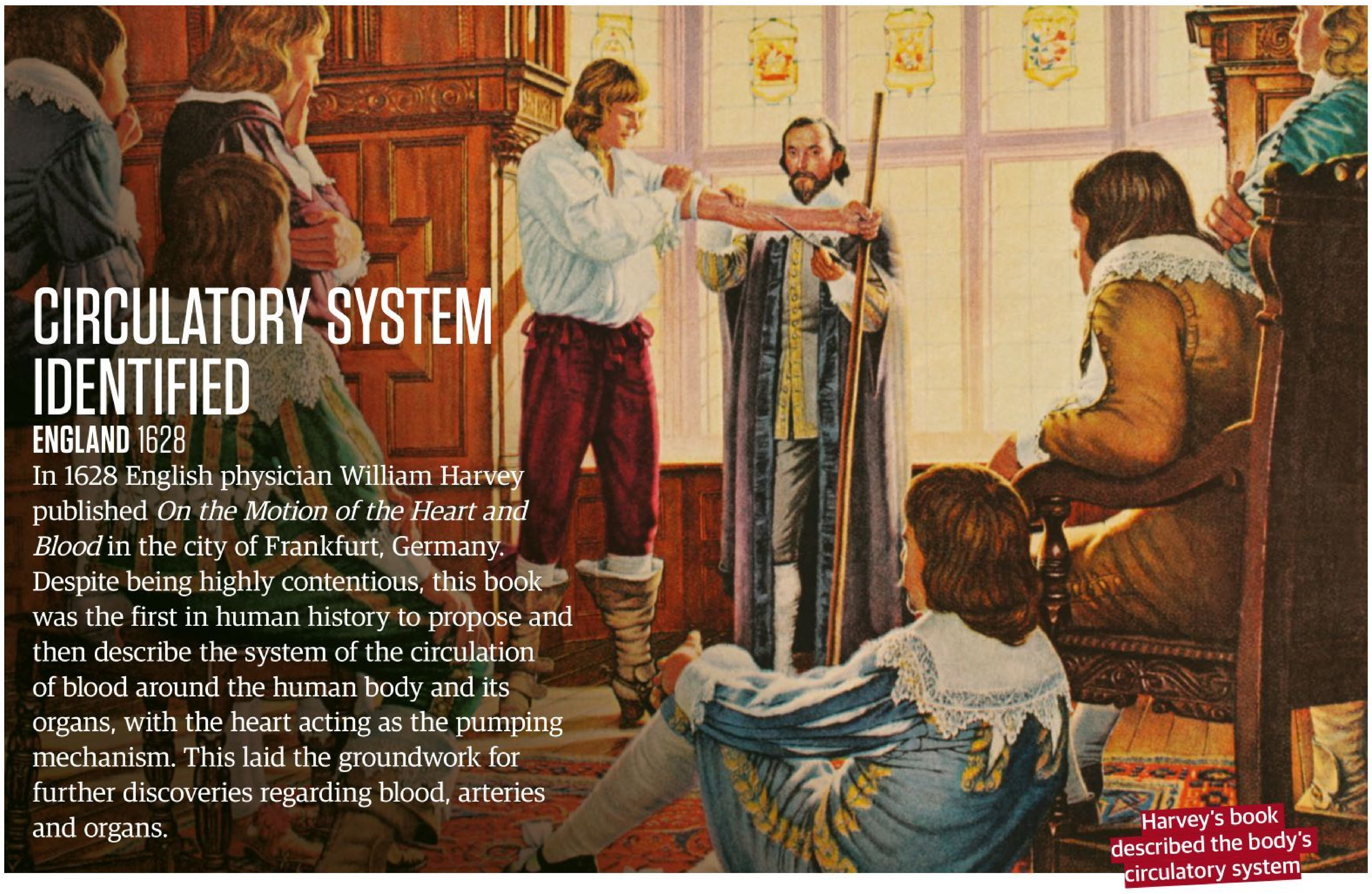
Plague doctors were a common sight duriing the Black Death

Blood groups defined

AUSTRIA 1901

Today we take blood groups for granted, with each individual aware of their specific type. This has made any procedure where blood transfusions are necessary considerably safer, with patient records enabling doctors to source the correct blood type. However, the main human blood groups were only defined in 1901 by Austrian biologist and physician Karl Landsteiner. Thanks to this discovery, the first successful blood transfusion was carried out on a human a few years later.


Karl Landsteiner's discovery saved countless lives



CIRCULATORY SYSTEM IDENTIFIED

ENGLAND 1628

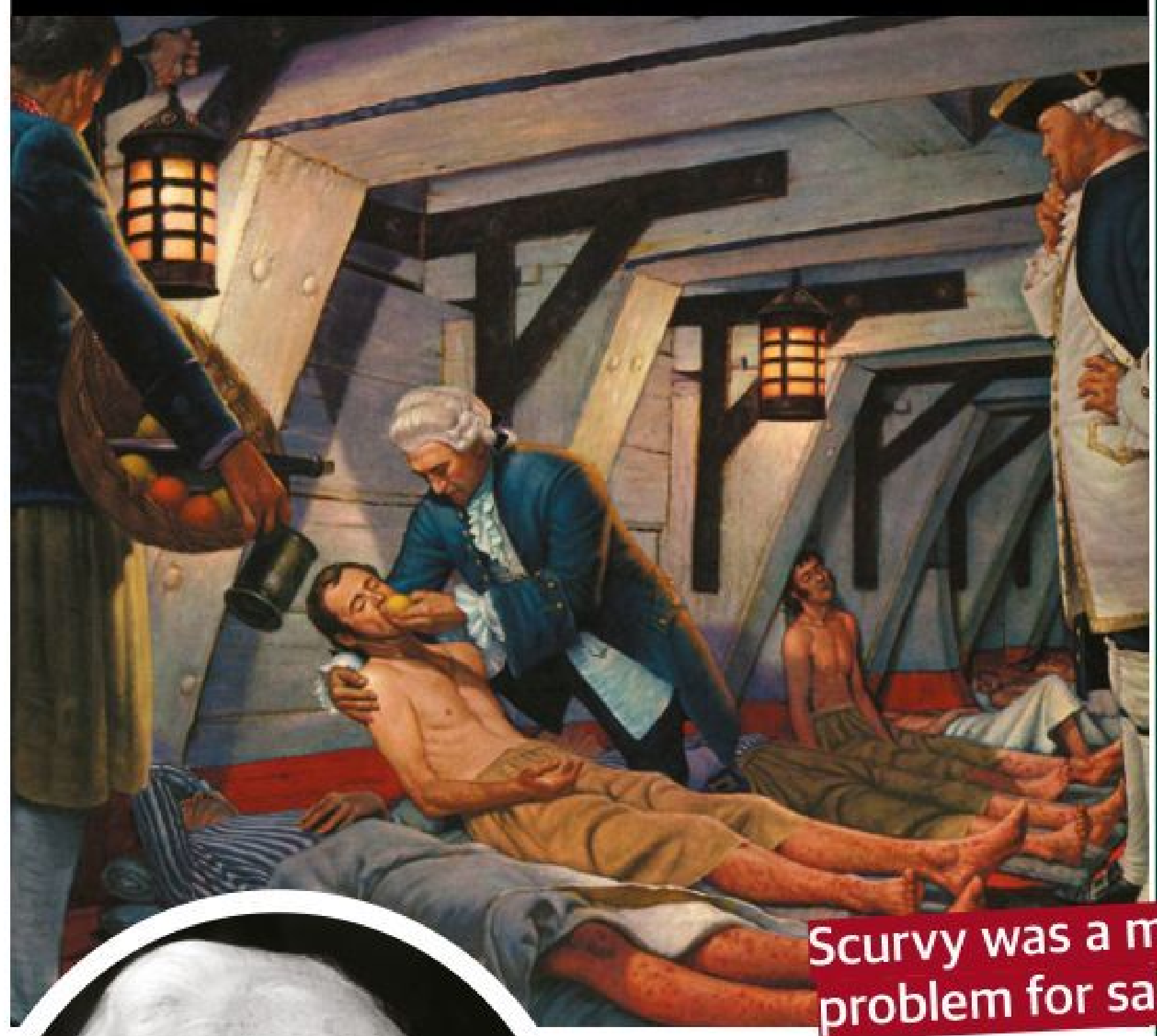
In 1628 English physician William Harvey published *On the Motion of the Heart and Blood* in the city of Frankfurt, Germany. Despite being highly contentious, this book was the first in human history to propose and then describe the system of the circulation of blood around the human body and its organs, with the heart acting as the pumping mechanism. This laid the groundwork for further discoveries regarding blood, arteries and organs.

Harvey's book described the body's circulatory system

Cure for scurvy

SCOTLAND 1747

Prior to the mid-18th century, scurvy – a disease resulting from a deficiency of vitamin C – was a major problem for sailors, with their months at sea depriving them of a balanced diet. In 1747, however, Scottish naval surgeon James Lind discovered that by consuming citrus fruits, which are a great source of vitamin C, scurvy could be largely curtailed, with him publishing his results in his *Treatise of the Scurvy* in 1753. Disappointingly it took around 40 years passing before lemon juice supplies were made mandatory on ships in the British Navy.



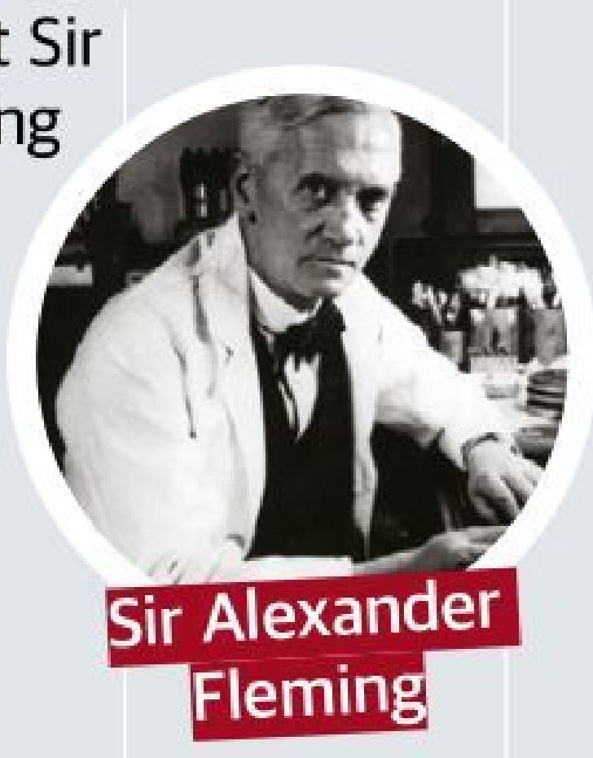
Scurvy was a major problem for sailors

Medical pioneer
Elizabeth Blackwell becomes the first woman to gain a medical degree, studying in America, and is also the first woman on the UK Medical Register. **1849**

Germ theory explained
Robert Koch and Louis Pasteur establish the germ theory of disease for the first time in history. **1870**

Robert Koch

Penicillin discovered
Scottish scientist Sir Alexander Fleming discovers penicillin by accident from a discarded Petri dish. **1928**



Sir Alexander Fleming

Measles combated
The first vaccine for measles goes on sale in the US and later around the world. **1963 CE**

Life-saving vaccine
The world's first vaccine for hepatitis B, a disease that has caused epidemics, is developed. **1981 CE**

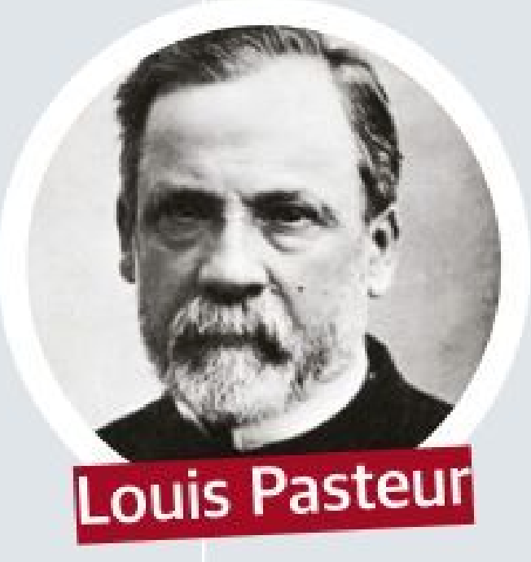
Willem J Kolff

Dialysis pushed
Willem J Kolff, a Dutch scientist, undertakes ground-breaking work into artificial organs and the practise of dialysis. **1985**

Organs are 3D-printed
Artificial organs – including heart valves – begin to be produced by 3D-printing methods. **2012**

1860 1880 1900 1920 1940 1960 1980 2000 2013

Rabies treated
Louis Pasteur produces the world's first vaccine for rabies. **1882**



Louis Pasteur

Pain relief
Felix Hoffmann, a German chemist, becomes the first scientist to synthesise medically useful forms of heroin and aspirin. **1897**

Rickets rounded-on
Edward Mellanby discovers that it is a lack of vitamin D in the diet that causes rickets. **1921**

Beat again
Canadian inventor and titular Father of Biomedical Engineering John Hopps develops the world's first cardiac pacemaker. **1950**

CAT-Scans
Robert S Ledley, a professor of biophysics and radiology, invents computerised tomography scanning. **1974**

Robert S Ledley

HIV discovered
The virus that can lead to AIDS is identified for the first time. **1983**

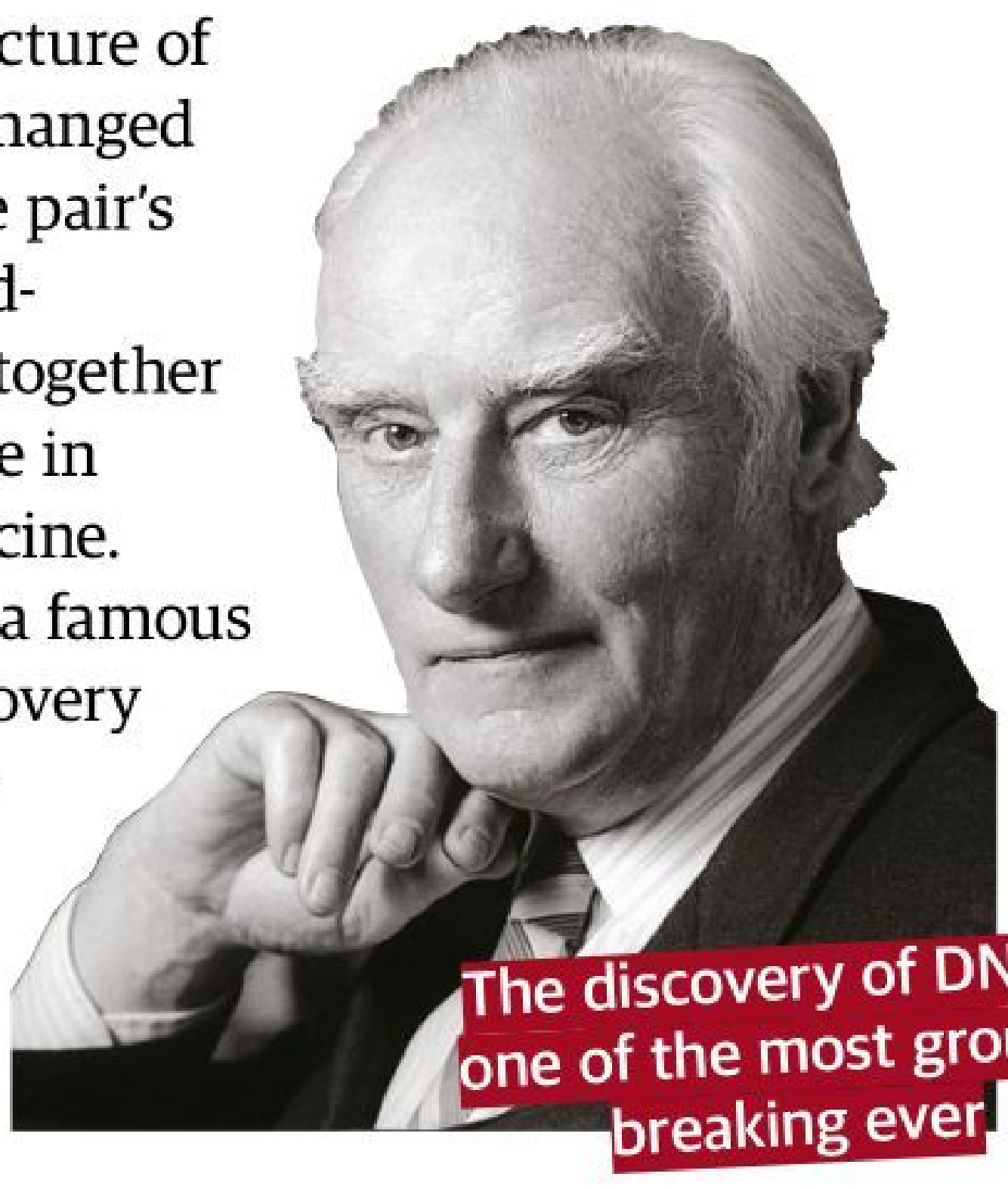
Dolly clone
Dolly the sheep becomes the first animal to be successfully cloned by human science. **1996**

Dolly the sheep

DNA discovered

AMERICA 1953

When James Watson and Francis Crick discovered the structure of DNA in 1953 they changed science forever. The pair's work was so ground-breaking that they together won the Nobel Prize in Physiology or Medicine. Watson later wrote a famous account of the discovery entitled *The Double Helix* and was also appointed head of the Human Genome Project.



The discovery of DNA is one of the most ground-breaking ever

Fertility boosted

ENGLAND 1978

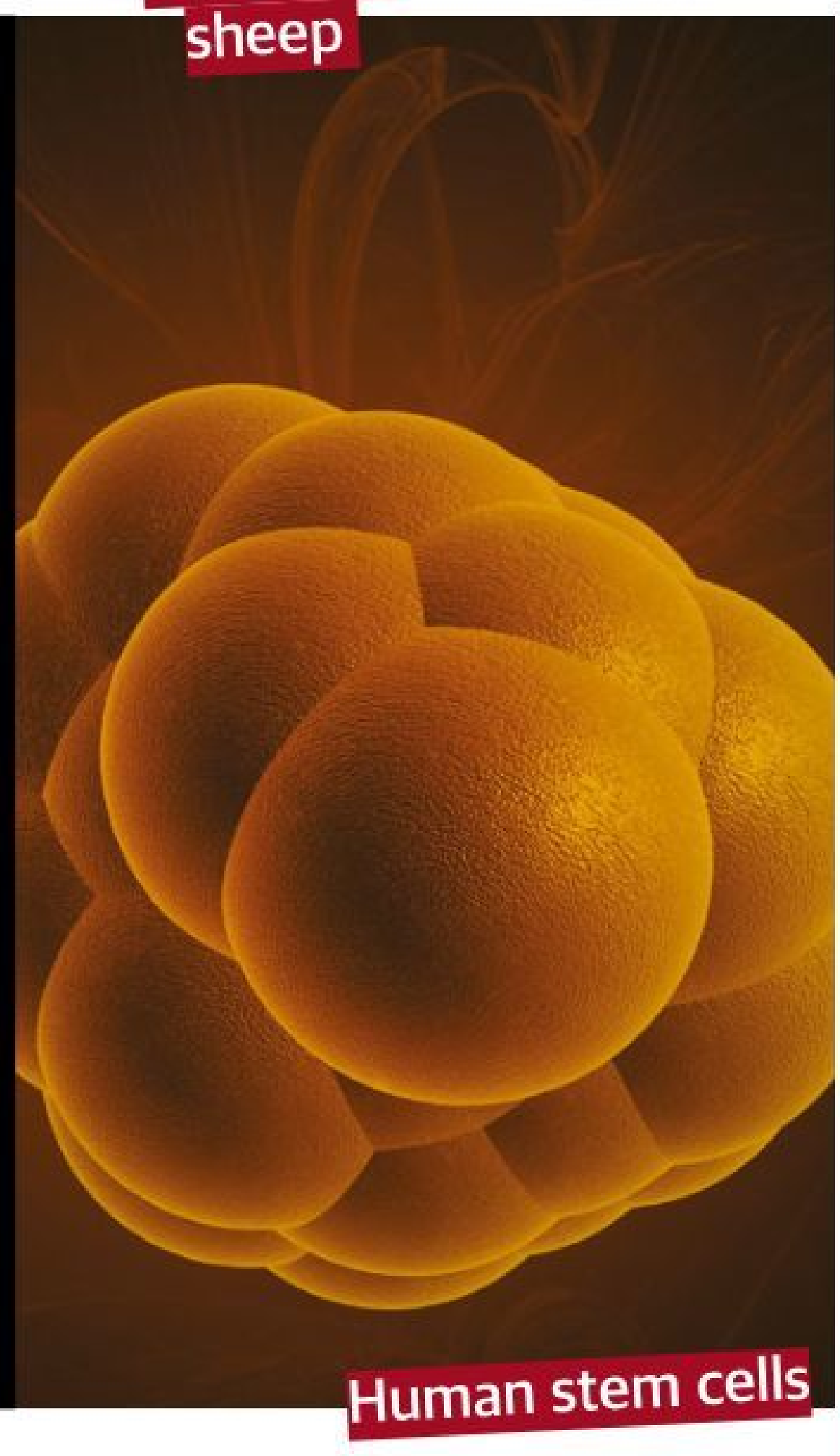
First developed by British scientists Patrick Steptoe and Robert Edwards in the Seventies, the process of in vitro fertilisation has transformed the ability of people with low fertility levels to reproduce. As of 2013, over five million babies have been born via in vitro, but this movement didn't start until the first test-tube baby was born under the scientists' care in 1978.

Over five million babies have been born due to in vitro fertilisation

Stem cell science

AMERICA 2007

The discovery of stem cells – undifferentiated biological cells that can differentiate into specialised cells and divide through mitosis to produce more – was a massive discovery for human science and one that has many exciting potential applications. This discovery was added to when scientists found that they could use human skin cells to actually create embryonic stem cells, thereby generating a faster and more viable way to produce them en masse.



Human stem cells

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MAGIC & MEDICINE

From bizarre treatments steeped in superstition to surgical procedures still in use today, this is the fascinating world of healing in Ancient Egypt

Take a stroll through the history books and it's hard to ignore just how weird and gruesome the world of medicine was in ages gone by. And the kingdoms of Ancient Egypt were no exception, either. Over its 3,000 years of existence, Ancient Egypt became an epicentre for culture, art, architecture and engineering. Records, such as the Edwin Smith Papyrus, have revealed that the time of the pharaohs also produced an incredibly broad approach to ailments and disease. This was an age where science, magic and religion were one. Sages, physicians and healers were all part of the same potent superstition and created an ancient medicinal cabinet that aided health.

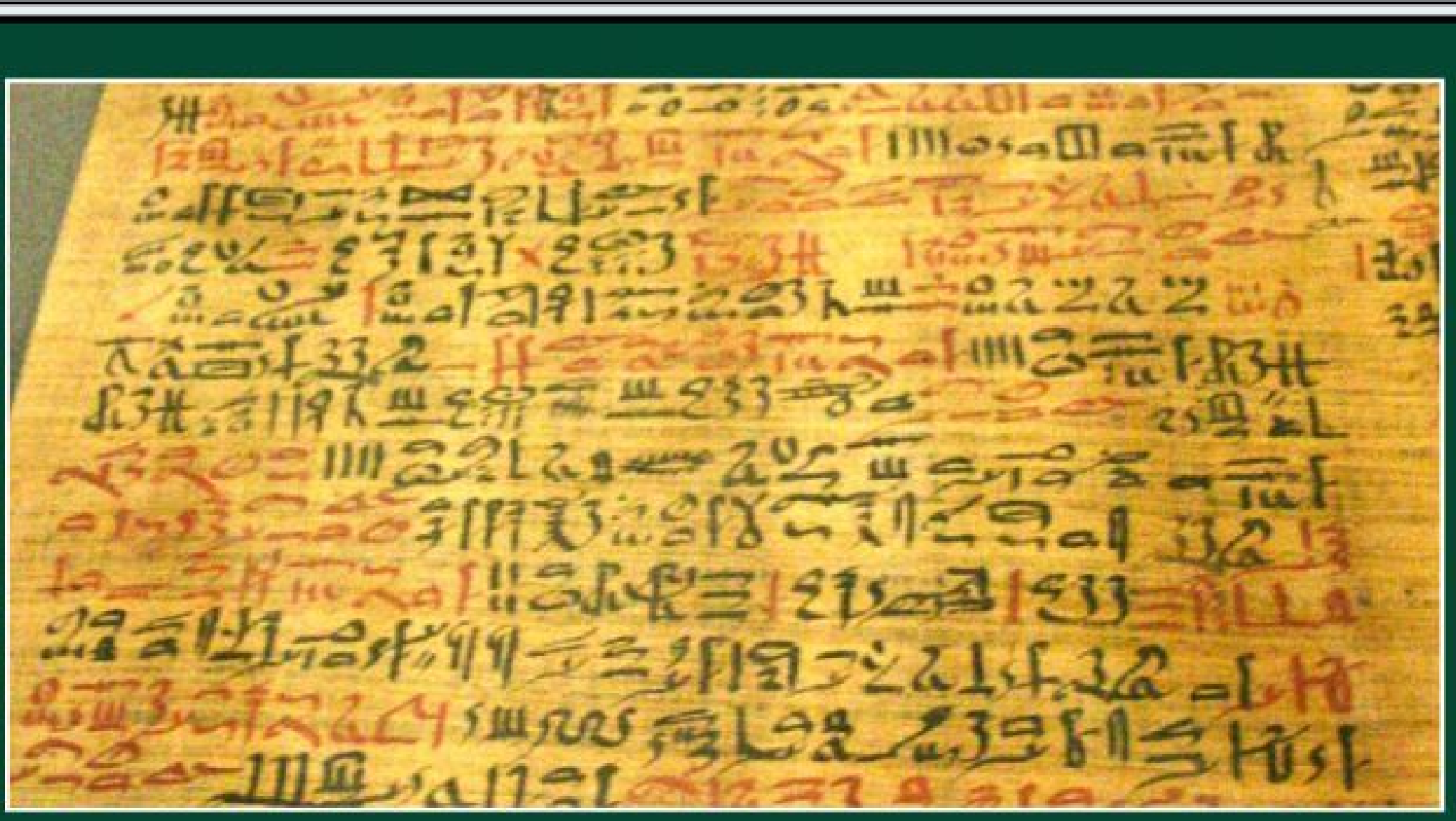
However, those medical treatments were all well and good if you could last long enough to actually receive it. The pharaohs may have been off conquering far away lands and building monuments that seemingly pierced the sky, but for the normal Egyptian folk who weren't lucky enough to bathe in milk and be washed in oils every day, the Egypt of the ancient world was a dangerous and merciless place to live. Diseases ran rife in cities, while deadly parasites lurked in the purportedly life-giving waters of the Nile. Egypt was a place of ambition and innovation, but it was also a land of death. Life expectancy was, in a word, terrible. Records imply mortality rates in infants were catastrophically high, and for those who made it into adulthood, those senior years were short-lived at best. Women tended to live no later than their early- to mid-20s, while men fared marginally better with mortality rates in the mid- to late-20s. These figures could well have worsened still during the 'dark periods' of Ancient Egyptian history (otherwise known as the First, Second and Third Intermediate Periods), when the breakdown in civil government and the influx of foreign people and external pathogens may have made such a poor situation even more worse.

A healer wouldn't just tend to the rich and the poor – one discovered relief shows a physician attending the childbirth of a queen

Much of our understanding comes from the preserved remains of Egypt's ancient citizens and nobles. It's from these age-old cadavers we can infer some intriguing details about the diseases and health hazards faced by those who won the mortality lottery of infancy and young adulthood. Infections of the eye were common, as one would expect living in a North African country surrounded by wind-whipped sand. Poisoning also seems to have been quite common, more from the treatments than anything else – scorpions and serpents were sometimes used to treat afflictions, and some could cause blindness, paralysis and even death.

Priests and doctors weren't always one and the same, but many shared positions in both areas, such as this priest depicted treating a musician for blindness

THE EBERS PAPYRUS



The papyri unearthed in the last few hundred years have radically changed our understanding of ancient Egyptian medicine. Egyptian doctors recorded countless procedures and diagnoses in detail, creating a unique insight into how a healer in this era identified and treated everything from inflammation to depression.

The Ebers Papyrus, purchased by German Egyptologist Georg Ebers in the winter of 1873-1874 in Luxor, is one such document. A 100-page scroll roughly 20 metres long, the papyrus dates back to around 1550 BCE, making it one of the oldest medical papyri ever discovered. Another early medical document, the Brugsch Papyrus (1300-1200 BCE) provides similar information to the Ebers.

The Ebers Papyrus covers a wide variety of ailments, illnesses and disorders, as well as over 700 remedies and treatments. It contains incantations and spells to banish disease-causing demons alongside incredibly detailed – and accurate – descriptions of the heart. The Egyptians correctly identified that the heart was at the centre of the body's blood supply. The papyrus also states that the heart is responsible for pumping four separate fluids around the body – blood, urine, tears and semen – much in the same way medieval doctors believed the body was based on a balance of very similar 'humours'.

A number of instances of tuberculosis, or more specifically spinal tuberculosis have been found, as have traces of kidney stones (which can be deadly if not treated accordingly). Evidence also suggests outbreaks of polio, influenza and smallpox across the different eras of Ancient Egypt. Plague was an issue too, just as it was in medieval and early modern Europe, over a thousand years later. A 'year of pestilence' was recorded that made reference to a potential outbreak of plague, but, like most aspects of a time this far in the past, it remains in conjecture.

Then there was the Nile. The lengthy river was the lifeblood of Ancient Egypt; it was thanks to its proximity that the earliest pharaohs could sow healthy crops in a Saharan environment, while turning the swampland of the Delta (a series of small rivers and tributaries that poured into the Mediterranean Sea) into one of the most agriculturally lush and fertile stretches of land in the world. And yet it also proved as much a danger to the Egyptians as a life-giving treasure.

> Some prescriptions were remarkably close to modern standards, but some were bizarre – such as the use of bacteria-filled dung

The Nile was teeming with parasites, so for those who bathed in it or drank from it, the chances of becoming ill were likely considerable. Those who went wading through its cool waters, most notably along the irrigation channels, were in danger of crossing paths with parasites like the Schistosoma worm. This dastardly little blighter would bore its way through your feet or legs and lay eggs in your bloodstream. These worms would hatch and work their way through the body, causing a terrible amount of harm and making the host sick and frail. And for those who dared to drink water from wells that drew on the Nile, they risked the chance of ingesting guinea worms. Female guinea worms would often travel through the body to a suitable nesting site, usually the legs, and force a host into a weak and sickened state.

So how did the Egyptians hold back the shadow of Osiris, the god of death? Despite their distant place in history, Ancient Egyptians were quite advanced in their ability to diagnose a variety of ailments and illnesses (both long-forgotten and familiar). The remedies they used were almost entirely drawn from nature, so many of them have survived to today as modern herbal medicines and alternative treatments.

Almost all of our knowledge of these diagnoses come from the incredibly detailed records in the Edwin Smith Papyrus (c. 1600 BCE), the Berlin Medical Papyrus (c. 1250 BCE), the Kahun Papyrus (c. 1900 BCE), the London Medical Papyrus (c. 1250 BCE) and the Ebers Papyrus (c. 1600 BCE) – each of which details the Egyptians' knowledge of disease, anatomy and healing. These texts express an incredibly precise understanding of human anatomy – the practice of mummification gave those involved a deeply intimate knowledge of the body's composition and natural balances. And considering that many physicians were also priests, it seems possible surgeons would have cut their teeth in the sanctity of mummification before getting to grips with the living. And that intimate knowledge was what gave the Ancient Egyptian healer the power to deal with almost any ailment.

"When you come across a swelling of the flesh in any part of the body of a patient and your patient is clammy and the swelling comes and goes under the finger," reads the Ebers Papyrus (c. 1500 BCE) in regards to diagnosing swelling and a potential tumour, "then you must say to your patient: 'It is a tumour of the flesh. I will treat the disease. I will try to heal it with fire since cautery heals'. When you come across a swelling that has attacked a channel, then it has formed a tumour in the body. If when you examine it with your fingers, it is like a hard stone, then you should say: 'It is a tumour of the channels. I shall treat the disease with a knife.' "

The use of fire remains an alarming means of treating any sort of swelling, but the most striking element is the bedside manner. Here we see an aspect of Ancient Egyptian medicine that's often missing from medical information from other ancient cultures, and one that typifies the importance of sages, healers and physicians in Egyptian society. During this time, the mental welfare of a patient was just as important as the ailment affecting them physically.

Surgery was another important factor of day-to-day Ancient Egyptian medical practice. More importantly, it wasn't a speciality as it is now, but a necessity for every physician to know and practise whenever and wherever it was needed. Most procedures that took place, according to the evidence we have to draw from, were focused on external trauma, and none was ever conducted inside the body. Interestingly, many of the surgical procedures we commonly see today - eye surgery, dental surgery and those involving childbirth - were either never performed or no evidence has been found to confirm their existence at this time. More bizarre still is that no records exist relating to dental or eye surgeries involving nobles or even the pharaohs themselves - an especially curious factor when you consider the importance of the eye in Egyptian symbology. The only evidence available confirms the use of topical remedies for eye maladies and nothing more.

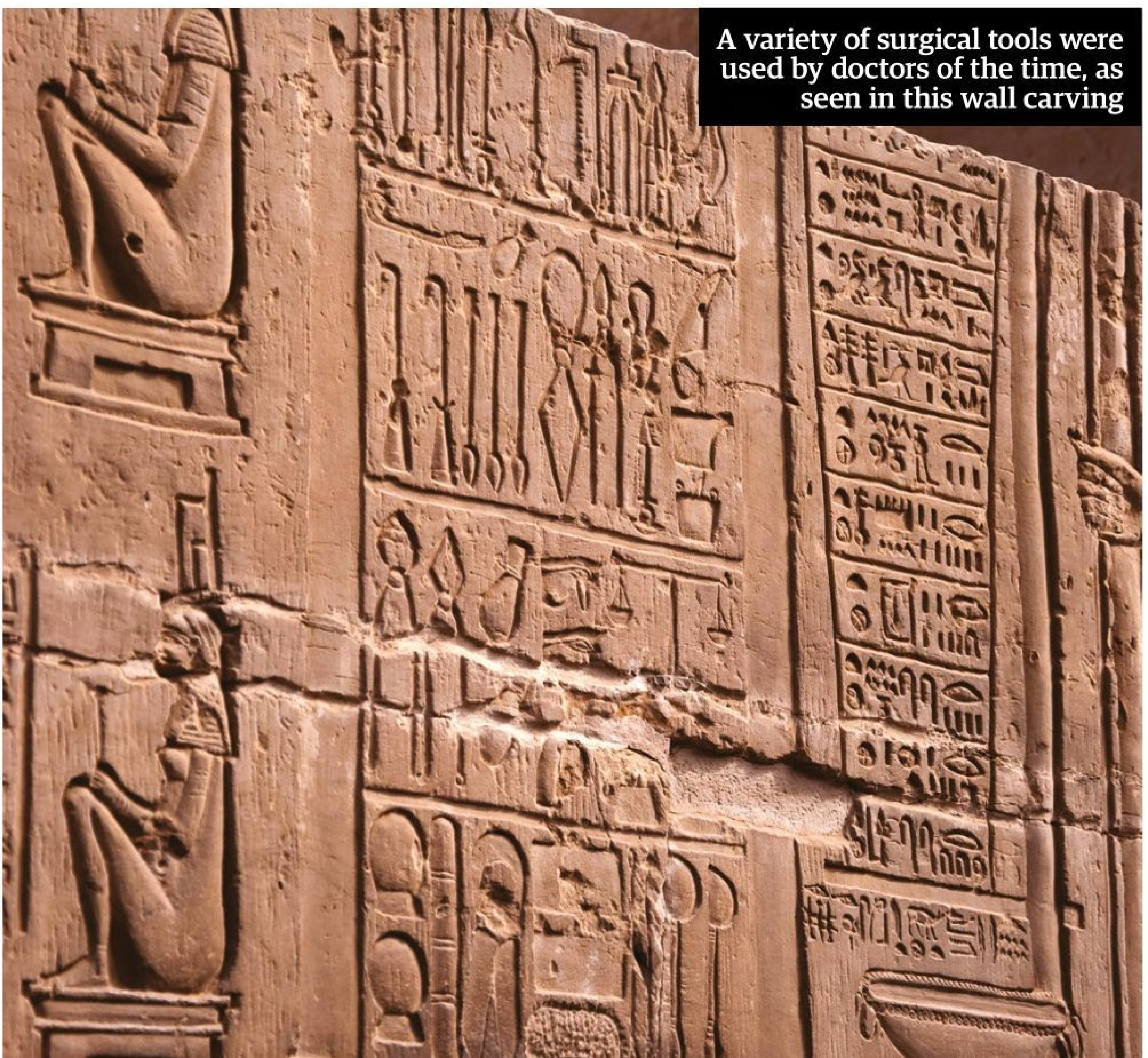
Surgery became an advanced part of Ancient Egyptian medical practice because, unlike other civilisations at this stage in their development, the Egyptians had already developed a robust written language. This enabled physicians and healers to record certain diagnoses and treatments, and mark those that worked and those that didn't. Sadly, no early medical textbooks have survived from this period, but texts such as the Edwin Smith Papyrus are believed to have been based on such notes and collected experience, hence the importance they play in our understanding of how such practices were conducted.

The Egyptians divided potential surgery cases into three separate categories: treatable, contestable and untreatable. A treatable case was something a physician could solve immediately, while a contestable diagnosis was based on the assessment that a patient could survive in their current state. If the patient showed resilience, a healer could then select the appropriate surgical procedure to conduct.

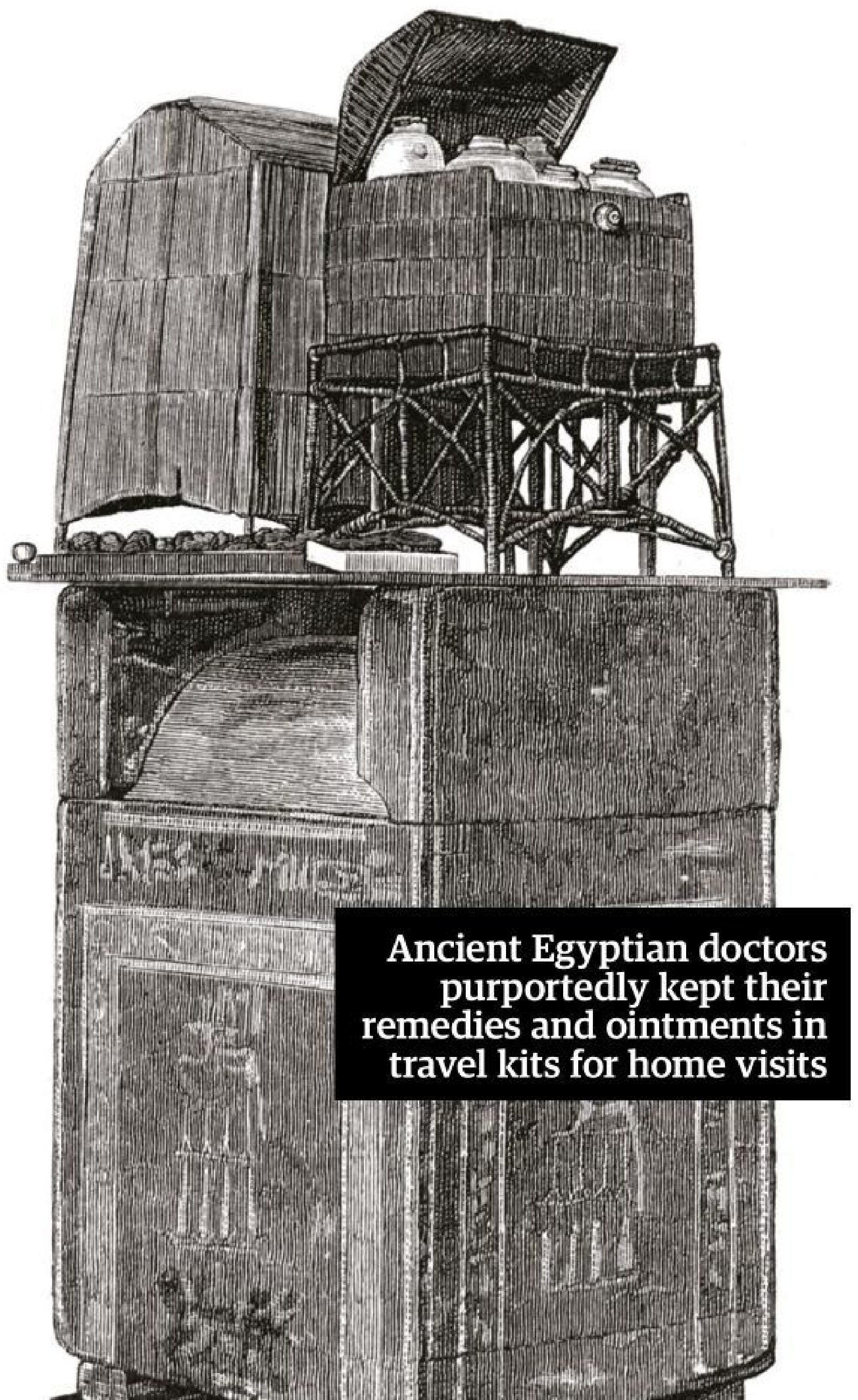
All surgeries were topical only. No invasive procedures were performed, purely because no forms of anaesthetic were available at the time, save alcohol. We know that the Egyptians reset bones with splints and stitched up large open wounds and complications of the skin. They were also, rather unsurprisingly, extremely adept at the use of bandages.

But that doesn't mean healers weren't afraid of using a blade as part of their treatment. The practice of circumcision was also performed by physicians. Although we don't know whether this was ever performed as a cultural or religious requirement, but the recovered papyri make

> The healing arts were a closely guarded profession and many doctors passed the knowledge down from father to son



A variety of surgical tools were used by doctors of the time, as seen in this wall carving



Ancient Egyptian doctors purportedly kept their remedies and ointments in travel kits for home visits

A startling level of patient care was employed by ancient Egyptian healers

Day in the life of a healer

6am
Since medicine was deeply rooted in the religious doctrine of ancient Egyptian society, a healer would have likely begun their day in the temple. Sekhmet, the goddess of healing, would have been the likely point of tribute, as well as other smaller deities such as Heka or Serket.

8am
A doctor would have treated anyone with an ailment, but it is likely the elite would have been the priority on a given day. We could easily expect a healer to be called into the home of a noble or even the palace in the middle of the night, should an incident arise.

10am
Doctors of this time may have operated from a specific building (especially for procedures and surgeries), but they would have often conducted house calls around the city. As you would expect, a healer would bring a number of pre-prepared remedies and tools with them.

12pm
A healer would also take the time to meet local and foreign traders in the markets or bazaars of the principality they work in. The success of a doctor's practice depended on the resources at their disposal, and it's likely they would source rarer items from traders and merchants.

3pm
A doctor might be called upon to operate on soldiers in times of war, or even those injured during the construction of a monument. Since no anaesthetics were available at the time, alcohol was used to dull the pain. Surgical procedures would be bloody, but doctors were proficient in treating wounds and amputations.

7pm
With most of his major cases and responsibilities taken care of, a doctor might have returned to the temple to consult with High Priests, or to simply find a quiet moment to reflect and be at one with the gods. A healer might have also had duties to attend to at the temple itself.

frequent reference to the uncircumcised nature of foreign peoples who they encountered.

A number of tools recovered from across the Ancient Egyptian eras have been identified as being involved in the rituals of mummification, which was a process in which internal surgery would have been required. Some of the tools recovered, including early forms of scalpel, suggest that such instruments must have existed for circumcisions, amputations and other operations to be performed.

Alongside the removal of cysts and tumours, cases of amputations being performed have been recorded. There was also a good chance of surviving such a gruesome experience; the experience of the Egyptian physician and a vast knowledge of the medicinal properties of the natural resources around them meant that these ancient GPs were capable of treating incredibly severe problems. An amputee, for instance, would have had their wound treated with willow or even cauterised in some cases.

That knowledge of natural remedies stretched far beyond surgery and fed into the everyday practices of a local healer. Mint and caraway were used to treat chest pains; mustard seeds, aloe and juniper were used to treat headaches; poppy seeds were used in the treatment of both insomnia and burns; camphor counteracted bouts of vomiting; mustard seeds were used as emetic when needed, while mint was used to stop the effects. As Egypt expanded its borders during the Old, Middle and New Kingdoms, new ingredients and remedies would have become available as traders from Libya, Canaan, Nubia and those from further afield in Asia arrived in Egypt.

However, all these records of anatomical knowledge and practical remedies seem to fly in the face of the deeply religious fabric of Ancient Egyptian society. Magic formed as much a part of the Egyptian view of the universe as science, so it's unsurprising that this broad theological view informed the practice of medicine.

The presence of demons or malevolent spirits were sometimes presented or diagnosed as being the cause of a particular ailment. By mindset, Egyptian doctors took a monistic view of ailments: there was no mental or physical distinction. That's not to say that these ancient healers ignored the welfare of the mind - the translations that make reference to putting the patient at ease and exploring the problem with them drive this point home - however, we can infer the mind was seen as a victim of an ailment rather than the actual cause. This does raise questions as to how the Ancient Egyptians would have approached or dealt with cases of mental health disorders, but with the intrinsic link to the most powerful churches of the time, consultation with High Priests and the visitation of temples to pray for divine intervention would be considered.

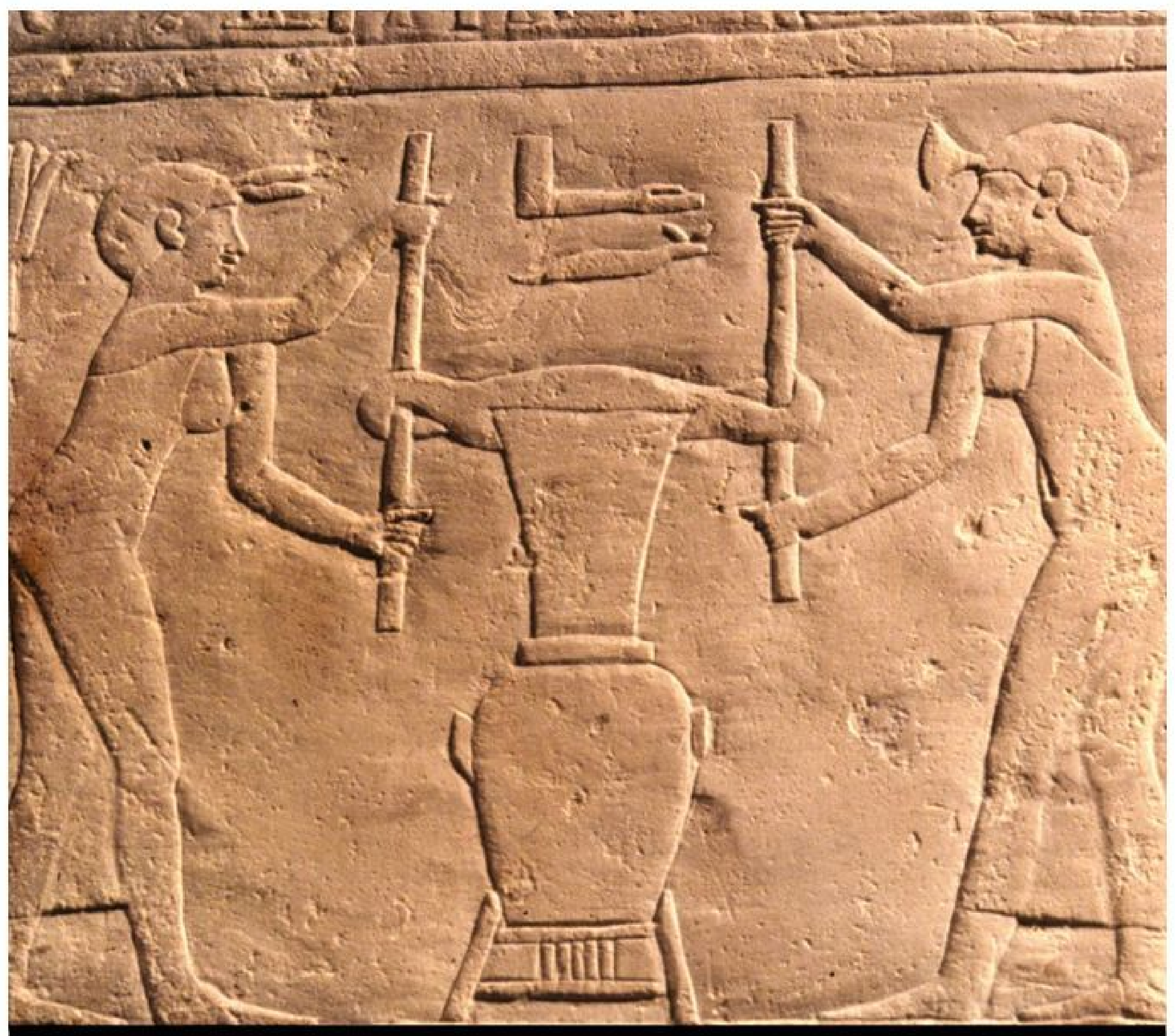
Practices also relied on a process known as 'sympathetic magic'. Like many other cultures, the Ancient Egyptians held a great deal of respect and admiration for the animal kingdom and believed the positive traits of a particular beast (courage, resilience, a hardy constitution) could be transmuted by the consumption or application of its flesh. For instance, a pig's eye might be used as part of a treatment to cure blindness, with the hope the animal's sight would pass over to the patient.

These practices, from the reciting of incantations to the application of a salve or remedy, all fed into the basic way in which a doctor viewed a patient's being: the channel theory. The concept worked much in the same way as the Buddhist chakra or the medieval European theory of 'balancing the humours'. The body, mind and soul were viewed as one, and were a series of 46 physical channels that ran through the body and intersected at the heart. In other words, they meant veins, arteries and intestines. It was a commonly held belief that demons and other forces would block these channels, causing internal strife.

Of course, the diagnosis of internal spiritual strife could easily be taken as a shorthand for Ancient Egyptian doctors having to balance a lack of understanding of more complicated medical issues with an intrinsic need to appease the deep-seated religious DNA of the time. It was perhaps their way of consolidating the two ideas.

Whatever the reasoning may have been, the healer of Ancient Egypt remains one of the most intriguing members of its society. And so it seems rather fitting that Imhotep, the polymath physician (a man often cited as the first true pioneer of medicine) would be deified a thousand years after his death and become a symbol of healing and care. The archetype of the Egyptian physician was just that: an individual of many talents who straddled multiple principles while bringing healing to the people of the kingdom.

> The Ancient Egyptians seemingly had a remedy for everything, including the use of aloe to treat epileptic fits



Most remedies and medicines administered by an Egyptian healer were taken from nature - such as the pressing and grinding of flowers

> "Magic formed as much a part of the Egyptian view of the universe as science"

Defining moment

Peseshet in control
2500 BCE

Peseshet, who lived during the Fourth Dynasty, is the first recorded woman to have been involved in medicine. Some credit her as a physician, but she was officially recorded as the 'lady overseer of the female physicians'. This reference alone is staggering - not only was Peseshet involved in the burgeoning medical marvels of her time, but there was also a contingent of female physicians in operation then. We know she existed because her son Akhethotep, an important dignitary, kept her stele in his *mastaba* in Giza.

Timeline

2650 BCE

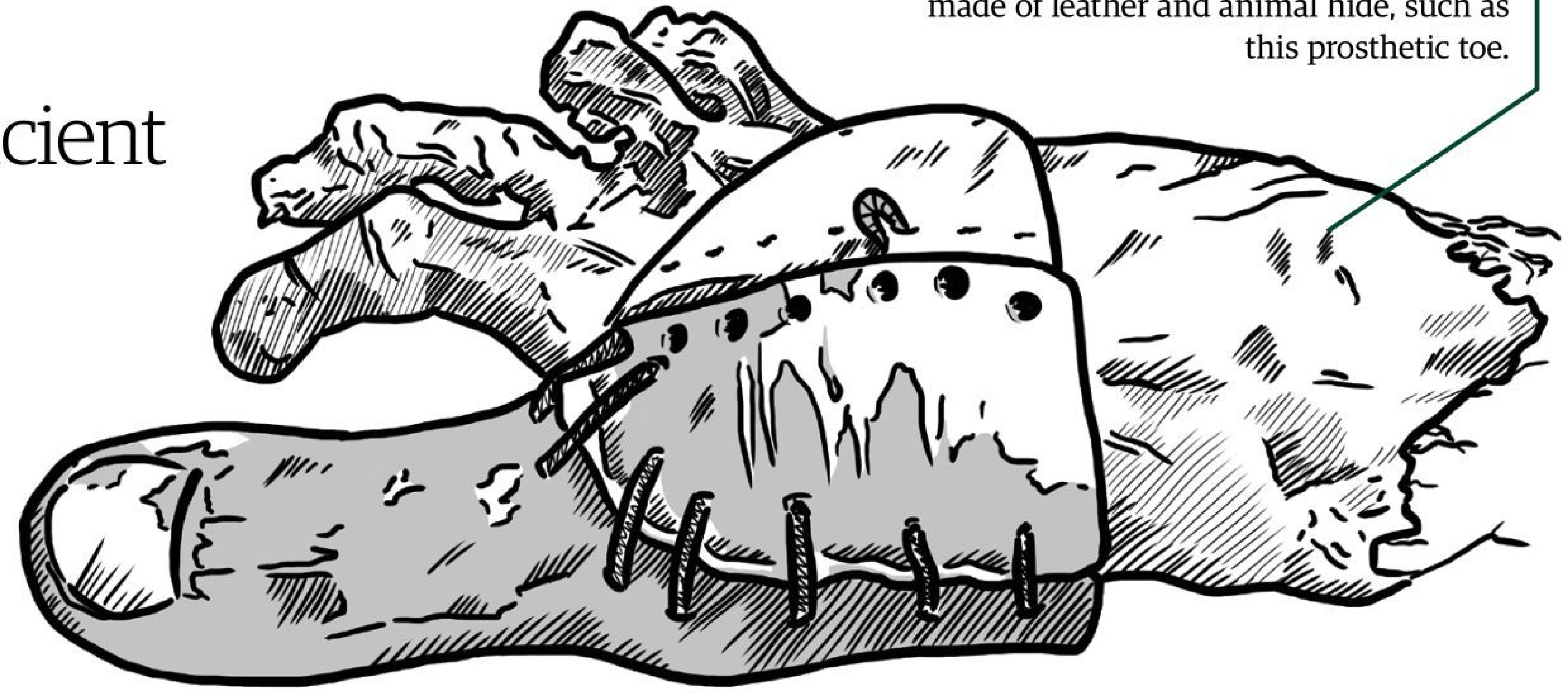
- **Imhotep is born**
  Around this time, the polymath and architect of Egypt's first pyramid is born. Imhotep is also rumoured to have authored the Edwin Smith Papyrus.
  2650 BCE
- **First recorded surgery performed**
  According to the Edwin Smith Papyrus and other resources, the very first instance of topical surgery is performed by an Egyptian physician.
  2750 BCE
- **Imhotep becomes healing demigod**
  Roughly a century after his death, the pioneer of Egyptian medicine becomes semi-deified as a god of healing and medicine.
  2700 BCE
- **Kahun Papyri written**
  A collection of texts is gathered together around the time of Amenemhat III's reign. These documents include a selection of hymns and medical records.
  1825 BCE
- **Kahun Gynaecological Papyrus written**
  Sometimes considered part of the Kahun Papyri, but an intriguing document in its own right, the Kahun Gynaecological Papyrus deals exclusively with women's health in ancient Egypt.
  1800 BCE

Tools of the trade

Taking a look inside the Ancient Egyptian healer's toolbox

Prosthetics

Since amputations were a common procedure performed by healers, prosthetics also played an important part in the rehabilitation process. Some were made of wood or wax, but many were made of leather and animal hide, such as this prosthetic toe.

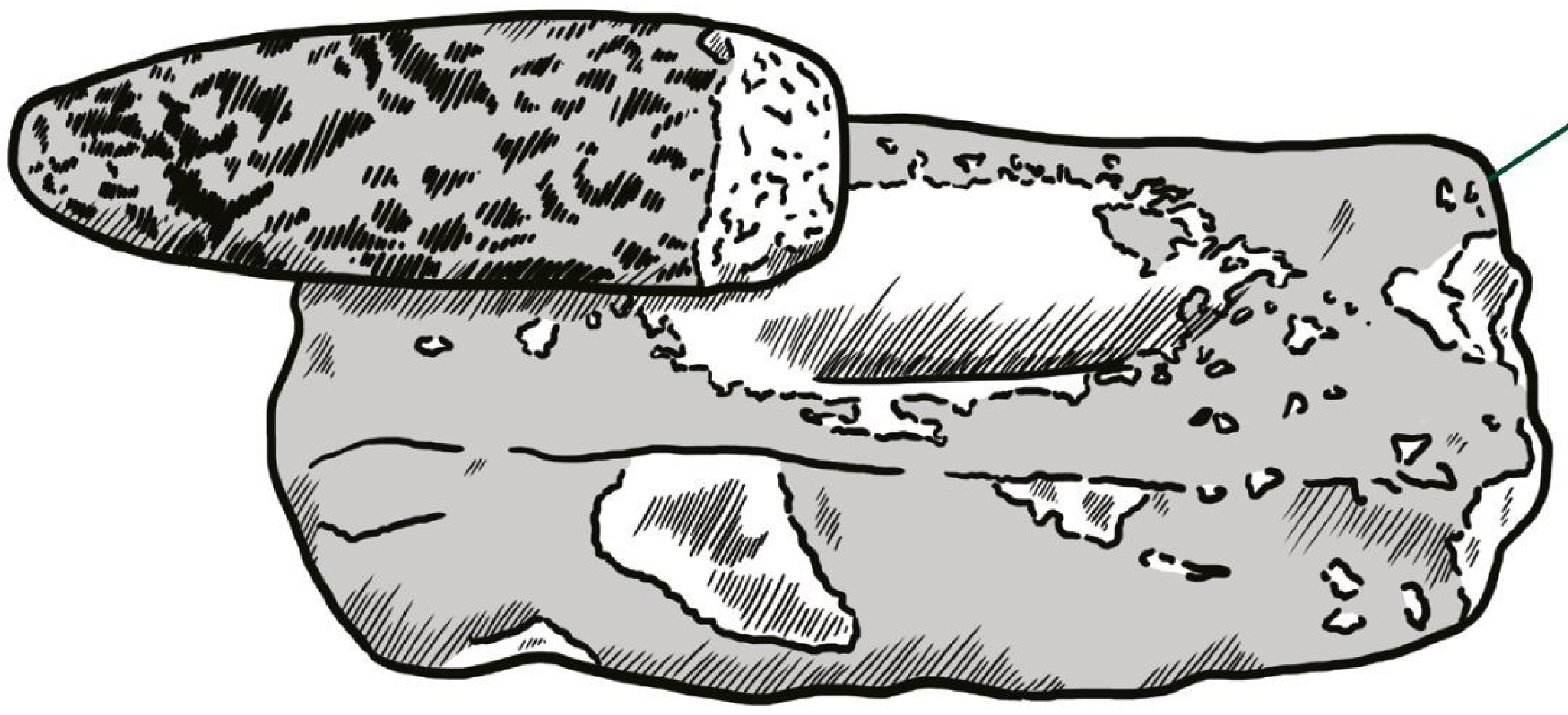


Scalpels and blades

While cutting tools were common in the practice of mummification, they were also an important part of a healer's medicine bag. Blades such as these would have been used to bleed blisters, cut away abscesses and more.

Pestle and mortar

The mortar and pestle played a vital part in a healer's everyday life – salves and pastes were often made from natural resources.

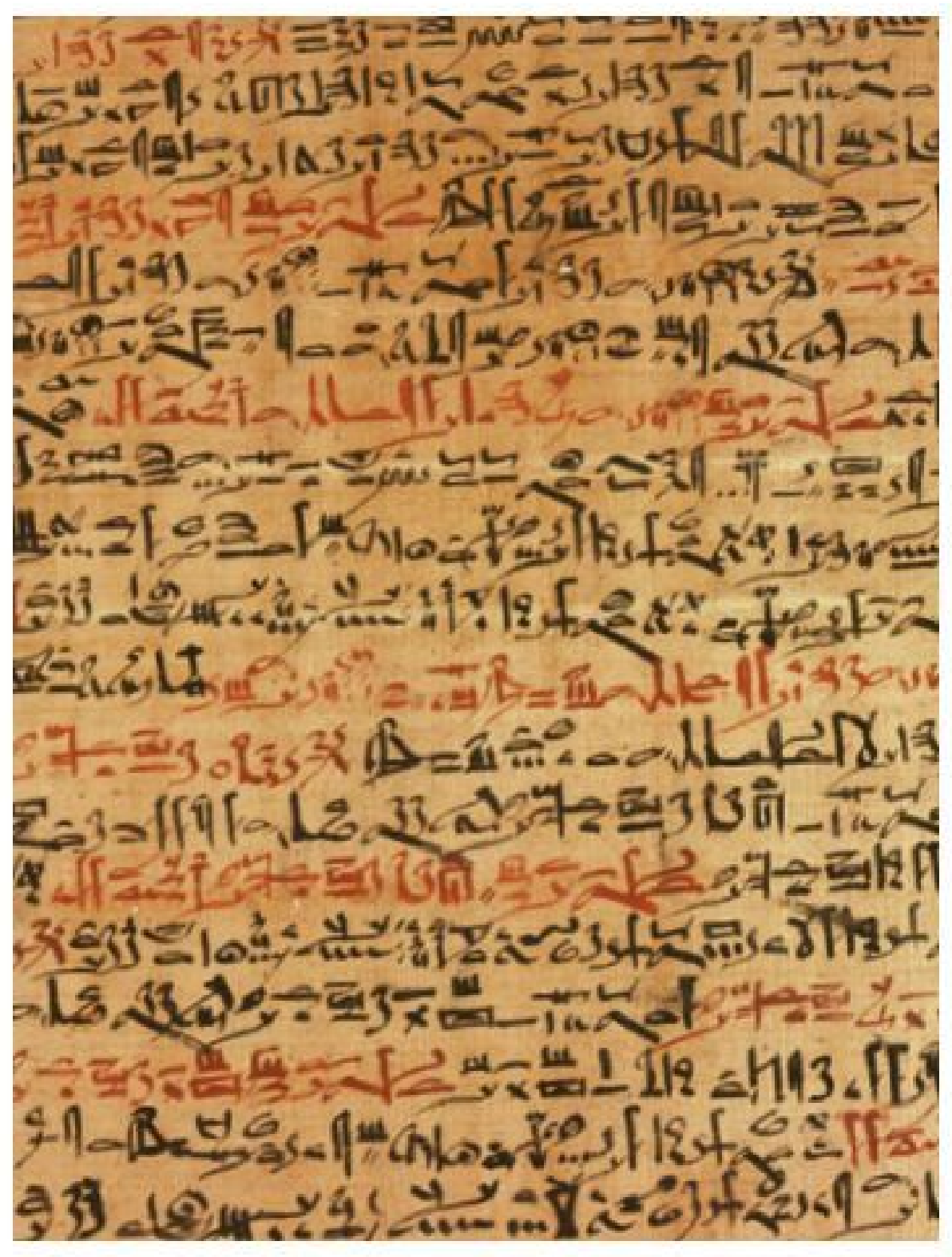


Defining moment

Edwin Smith Papyrus written

1600 BCE

This papyrus remains the most detailed and enlightening medical text recovered from the time of the pharaohs. It details 48 case histories, covering everything from infections to serious trauma. It lists the procedures for assessing a patient, including the recording of visual clues and smelling the wound, as well as the taking of the pulse. Interestingly, it is in the Edwin Smith Papyrus that the word 'brain' appears for the first time in recorded history.

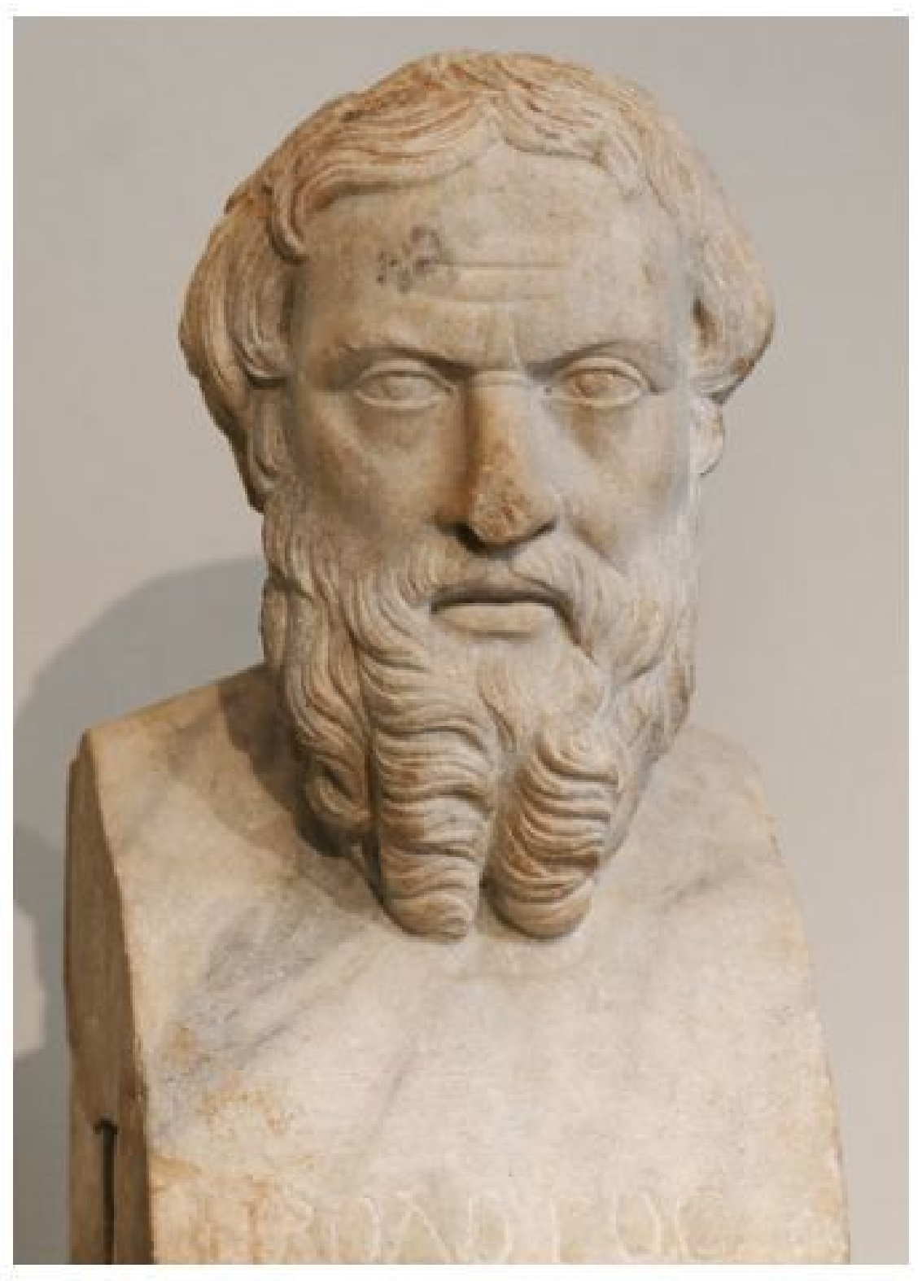


Defining moment

Herodotus visits Egypt

440 BCE

Greek historian Herodotus visits Egypt during the reign of King Cambyses II (the Persian monarch who successfully invaded and conquered Egypt) and spends most of his time in the Delta region. He records details of the mummification process and the practice of medicine at the beginning of the Persian occupation. However, some of his findings have been contradicted by archaeological discoveries.



Ebers Papyrus written
One of the oldest and most influential of the recorded medical papyri, the document is later bought from a dealer in Luxor (Thebes) in 1873.
1600 BCE

Berlin Medical Papyrus written
The Berlin Medical Papyrus, otherwise known as the Brugsch Papyrus, is a companion document to the Ebers' scroll and includes information on fertility and contraception.
1250 BCE

London Medical Papyrus written
This particular document mainly deals with remedies and treatments and lists a total of 61 recipes. 25 of these are considered 'medical', while the others are magical in nature.
800 BCE

Homer references Egypt
More of an epic poet than a traditional historian, Homer nonetheless includes references to Egyptian healers in *The Odyssey*, stating that "In Egypt, the men are more skilled in medicine than any of human kind."
800 BCE

Rosetta Stone decrypted
The Rosetta Stone is finally decoded, proving an invaluable cypher for reading and translating hieroglyphics. From this discovery, the famous medical papyri would spill their secrets.
1822

© Alamy; Abi Daker

THE FIRST DOCTORS

ANCIENT EGYPTIAN MEDICINE, CIRCA 1550 BCE

01 Washing hands

Egyptian doctors understood that hygiene was vital. However, they mistakenly believed that the water from the Nile was purified.

02 Utensils

Surgical materials were improved and become more precise due to the anatomical knowledge gained from the mummification process.

03 Professionals

Doctors were some of the most well-respected figures in Egyptian society. In their clinical practices they used medical equipment, remedies and prayers to the gods.

04 Assistants

Most doctors would have assistants to keep the patient immobilised and help with equipment. An assistant was also a sign of status.

05 Convalescence

The Egyptians did not know about anaesthesia, so patients would be conscious when operated on and treated. However, they did use different types of painkillers and drugs which helped to numb the patients' pain.

During the ancient Egyptian civilisation, the first of who from a modern perspective we would call doctors emerged. Imhotep is considered by many to be the first great doctor, and during the time period of 260 BCE the doctor, architect and priest diagnosed over 200 ailments and prescribed medical treatment for them all. Such was his influence that after he died he was worshipped as a god of healing.

That he was also a priest wasn't unusual as for the Egyptians – a god-fearing people with many different deities – treatment such as painkillers and cleaning a wound went hand in hand with asking higher powers for help. It was not uncommon for a witch doctor to accompany a doctor on their rounds, making the required spells aimed at making the treatment more effective. Despite this focus on the supernatural, ancient Egyptian doctors also made very important discoveries about how the human body worked, and they knew that the heart, pulse rates, blood and air were important to the workings of the body and that a weak heartbeat meant that the patient had serious problems.

An ancient papyrus has also been found that makes specific reference to our organs such as the spleen, lungs and the heart, which shows that doctors in their time could treat illnesses individually. In fact, there was a high degree of specialisation among Egyptian physicians, with some treating only the head or the stomach, while others were eye-doctors and dentists, and medical papyrus shows empirical knowledge of anatomy, injuries, and practical treatments. Doctors would perform tasks such as stitching wounds, setting broken bones and amputating diseased limbs.

These first doctors held highly prestigious positions due to their invaluable knowledge of different illnesses and treatments and their ability to read and write. They were trained in the medical schools of temples and travelled throughout the land to heal royal families and all those who could afford their expertise. Egyptian doctors used to commonly classify illnesses into three categories: those related to the action of evil spirits; to clear causes such as wounds, and those with unknown causes which were attributed to the will of the gods.

How do we know this?

Lots of information has come from first-hand sources, such as ancient papyrus, that have been discovered – the dry atmosphere of the country helping to preserve these – which provide lots of information about ancient Egyptian medical knowledge and practice. Archaeological digs have also found evidence of men titled as physicians, and hieroglyphics in tombs have made mention of Egyptian doctors.

07 Witch doctor

Despite having a good understanding of the human body, Egyptian doctors also believed in the power of the spirits to heal. A witch doctor would make the necessary magic spells to make the treatment more effective and increase the chances of success.

06 Pharmacopoeia

Remedies with medicinal properties were recorded in papyrus that included instructions on their preparation. It is through such material that much medical information from this period is still available.

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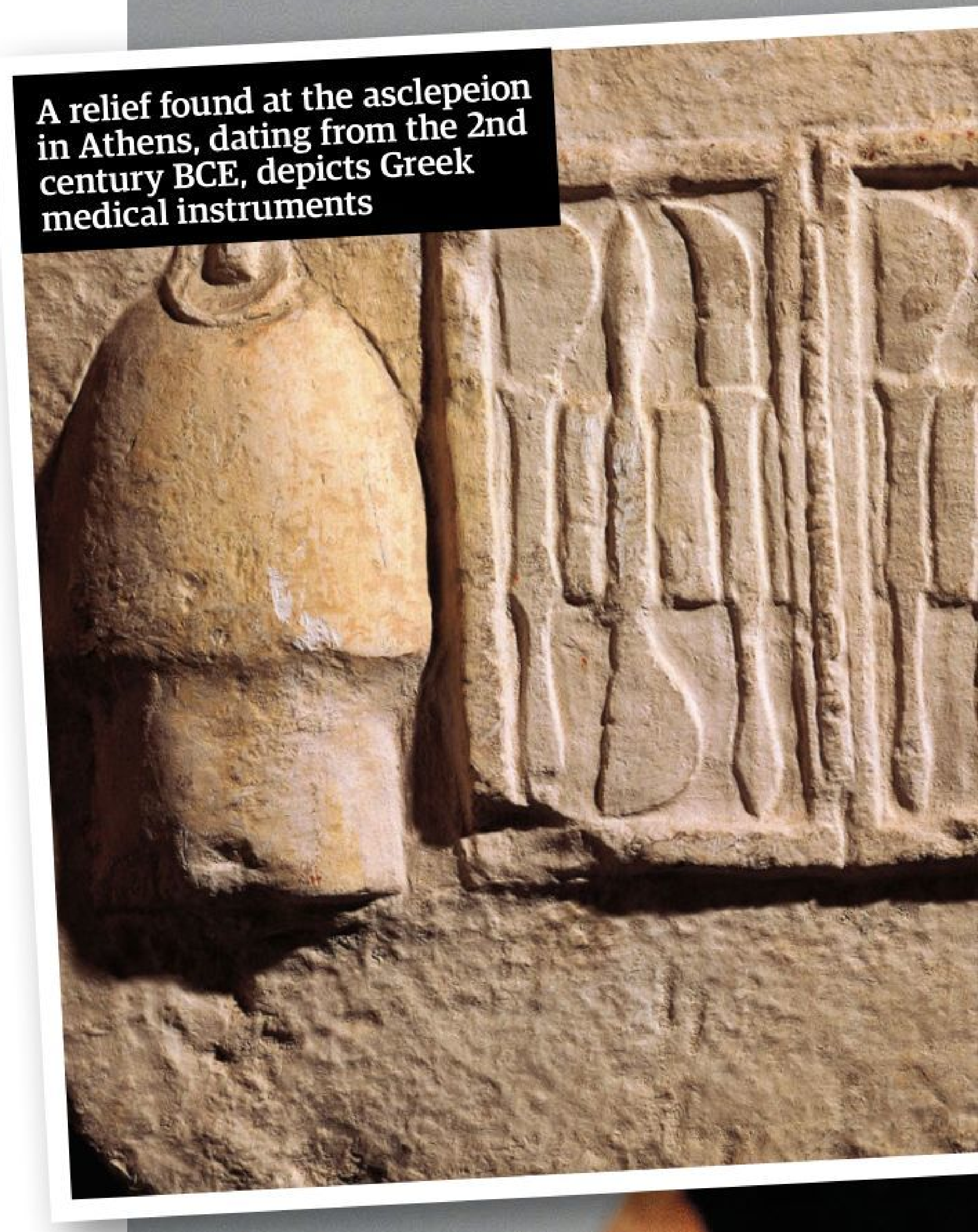

A relief found at the asclepeion in Athens, dating from the 2nd century BCE, depicts Greek medical instruments

ANCIENT GREEK MEDICINE

Though most of their theories about the human body have now been dispelled, in many ways the Greeks were the founders of Western medicine as we know it

Today, when we think of the Ancient Greeks, we'll often think first of their contributions to philosophy or the arts, or perhaps sport. But in ancient times, it was mostly for their medicine that they were renowned. Their practice marked the transition between spiritual and scientific methods, and they were the first in Europe to diagnose ailments using the modern technique of clinical observation.

Most historians now agree that the Greeks' main source of knowledge was Egypt, with the Minoans on the island of Crete possibly serving as the intermediary between the two civilisations. Some of Greece's most famous philosophers also spent time in Egypt, and they may have passed on the lessons that they learned there to aspiring physicians back home.

Pythagoras, who today is rarely associated with medicine, visited Egypt several times in the 6th century BCE, and his theories contributed greatly to the development of the field. He believed that music could purify the soul, and explored the effects of physical exercise on the mind and body. He also prescribed moments of contemplation at the beginning and end of each day, arguably making him an early advocate of mental healthcare.

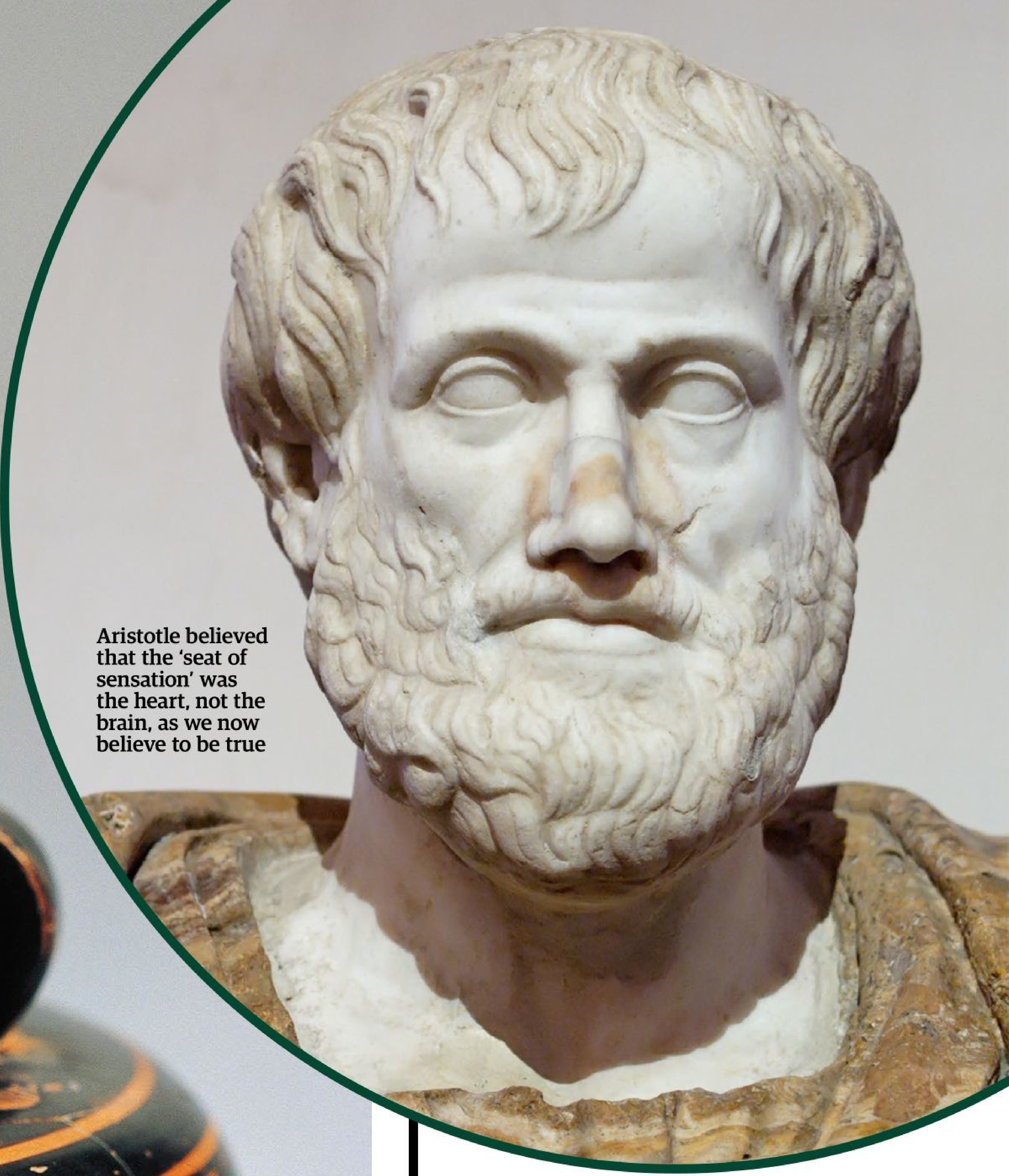
As in Egypt, the early Greeks believed that sickness was incurred by divine wrath, and so initially it was priests who were responsible for healing. Patients were to blame for their ailments and it was the task of the priest to conciliate them with the gods.

In the 5th century BCE, worship of the god of medicine, Asclepius, began, and healing temples known as asclepeia were established. The healing process at an asclepeion involved two steps. The first was purification, which involved bathing and perhaps following a clean diet for a number of days. The patient would then make an offering to the temple – often monetary – and spend some time in prayer.

The second step was called incubation. Patients would spend a night at the temple, and if they were incredibly lucky, one of the gods would come to them in a dream. The god would either heal them as they slept, or give them instructions on how they could be cured once they awoke. If no god came, a priest would interpret their dreams in the morning and, depending on the themes or imagery, they would prescribe treatment accordingly.

That was until Hippocrates came along. Born around 460 BCE, he would become known as the father of modern medicine. In his treatise *The Sacred Disease*, he argued that if all diseases had

Ancient Greek medicine has been considered to be the basis of modern scientific medicine



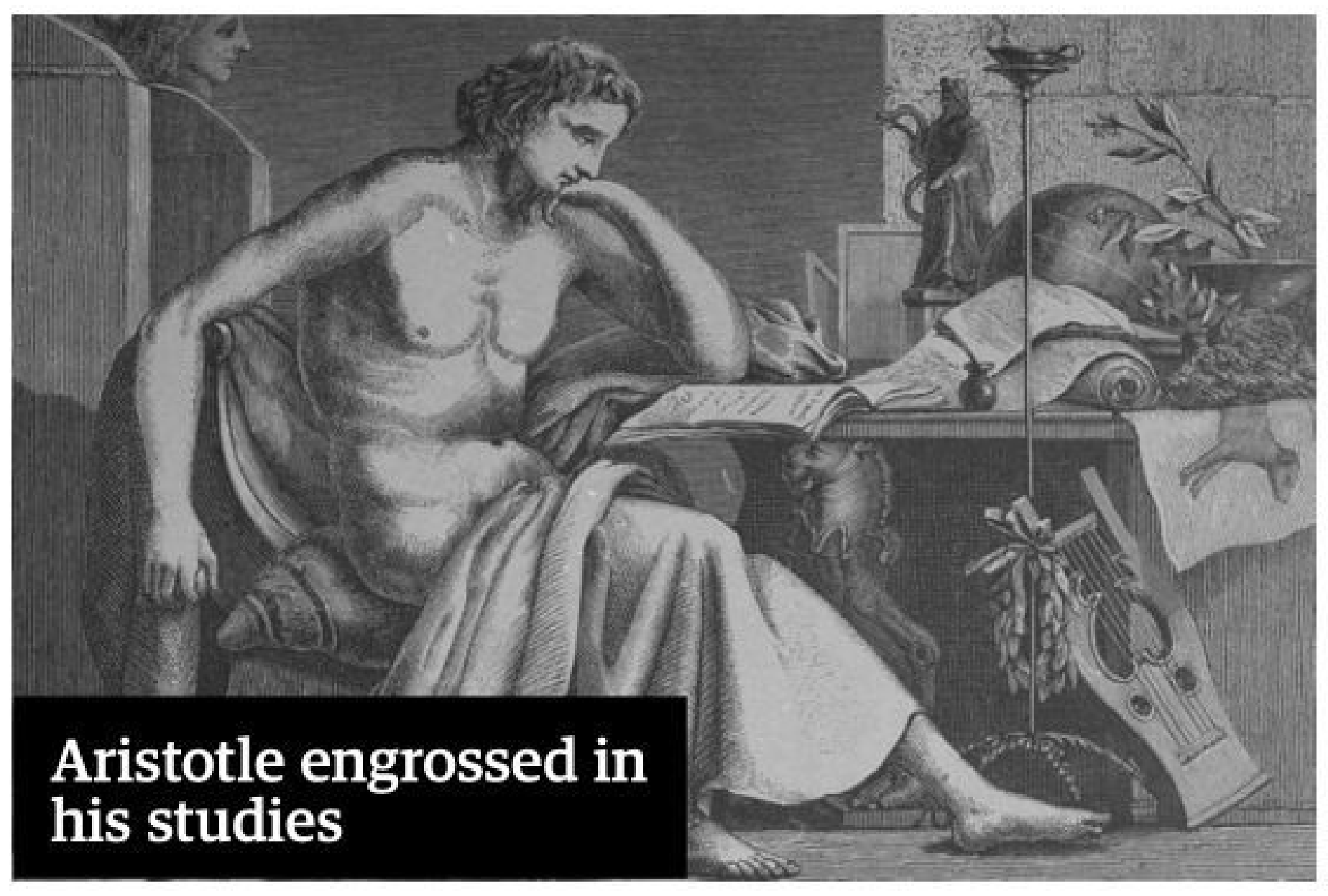
Aristotle believed that the 'seat of sensation' was the heart, not the brain, as we now believe to be true

Aristotle's biology

Aristotle was a great advocate of using empirical evidence when it came to understanding biology. However, he did not perform experiments, believing that a living thing only displays its true nature when in its own environment, and not when placed under artificial conditions.

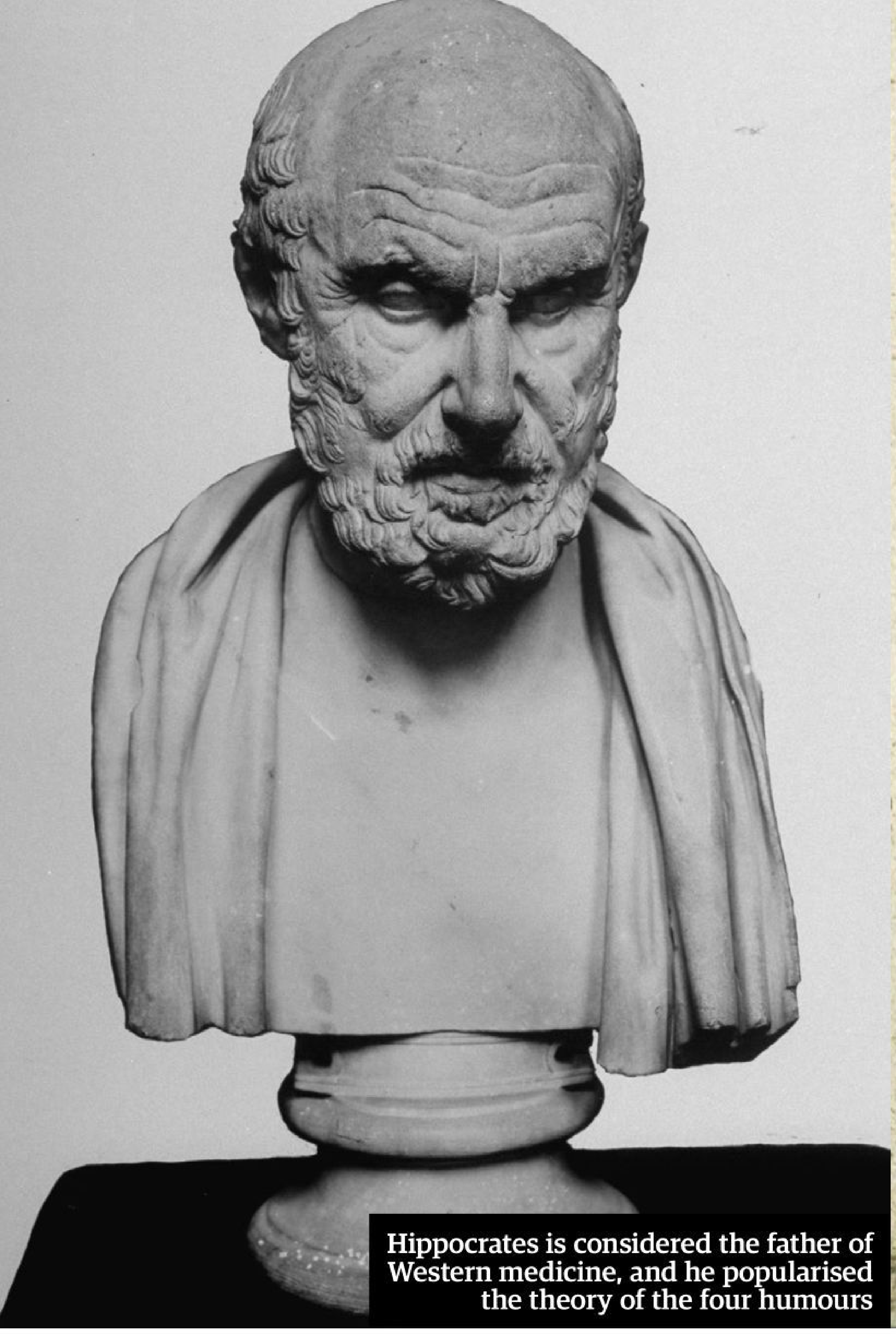
He spent much of his life observing the features and habits of plants and animals around him, classifying a total of 540 species. He categorised living things into three groups: a vegetative soul, responsible for reproduction and growth; a sensitive soul, responsible for mobility and sensation; and a rational soul, capable of thought and reflection. Plants fell into the first category, animals were capable of the first and second, and humans were capable of all three.

His information processing model explained how changes in the world led to a reaction by an animal: first, the change is detected by the sense organ, which leads to a change in the 'seat of sensation', which he believed was the heart. This causes an increase in temperature and so the heart transmits a mechanical impulse to a limb, which then moves.



Aristotle engrossed in his studies

Bloodletting – in which a person's veins were cut in order to reduce the amount of blood in the body – was a popular treatment in Ancient Greece



Hippocrates is considered the father of Western medicine, and he popularised the theory of the four humours

Galen was one of the most accomplished Greek medics, eventually settling in Rome and becoming personal physician to several emperors

supernatural causes, then biological medicines would not work. Instead, he placed the blame on an imbalance of the four 'humours': blood, yellow bile, black bile and phlegm. Being too hot, cold, dry or wet could disturb the balance and lead to illness. Though most treatments were benign - for example, a change in diet or increased exercise - the patient might also be 'purged' using laxatives and emetics, or the skin blistered with a hot iron. Bloodletting was also a popular procedure.

Hippocrates (rightly) believed that a person's environment could cause a disturbance - for example, the local water supply or the weather. Social class was also acknowledged as a factor, as poorer living conditions increased the chance of sickness. Patients played a big part in their own healing, in terms of decision-making and their mindset, and the belief that an individual could actually do something about their complaint overcame the more fatalistic attitude of earlier physicians. The issue of patient consent also came into question for the first time. The Hippocratic Oath, in which physicians promise to uphold certain ethical standards, is still sworn today - albeit in a modernised form.

> Hippocrates, the "Father of Modern Medicine", is the most important figure in Ancient Greek medicine

Hippocrates learned to record his patients' medical history and symptoms, observe their progress, and pass on his knowledge to other doctors in the form of books. The Hippocratic Corpus provided some of the earliest and most detailed studies of various ailments, although it is believed that around 19 different authors were responsible for its creation. Anatomical knowledge wasn't the strong point of Hippocratic medicine, as in Ancient Greece there was a ban on the dissecting of cadavers due to religious reasons. Instead, emphasis was placed on how the human body as a whole responded to its environment.

Late Greeks built on the ideas of Hippocrates, and learned to observe bodily functions, record their findings, and take their knowledge all over the known world. With no professional body to supervise or train them, anyone could begin practising medicine - all they needed was a willing patient. Despite this, physicians were held in high regard - just as they are today - with a line in Homer's *Iliad* stating "a doctor is worth many other men".

Medicine flourished under the Ptolemies, with Hellenistic Egypt becoming a centre of culture and learning. A 'school' was founded in Alexandria, which became the home of four of Greece's most famous anatomists: Diocles of Carystus, Herophilus of Chalcedon, Erasistratus and Praxagoras.

Diocles had a head bandage and an instrument for removing arrowheads names after him. Praxagoras was noted for distinguishing between veins and arteries. But for all their achievements, Praxagoras and Diocles clung on to the traditional belief that the heart was the centre of intelligence. Herophilus, on the other hand, asserted that the brain was responsible for conscious thought. He was also the first to connect the nervous system to motion and sensation. His discoveries were greatly aided by the fact that in Alexandria, the ban on dissection was lifted and he was given criminals

> "Medicine flourished under the Ptolemies, with Hellenistic Egypt becoming a centre of culture and learning"

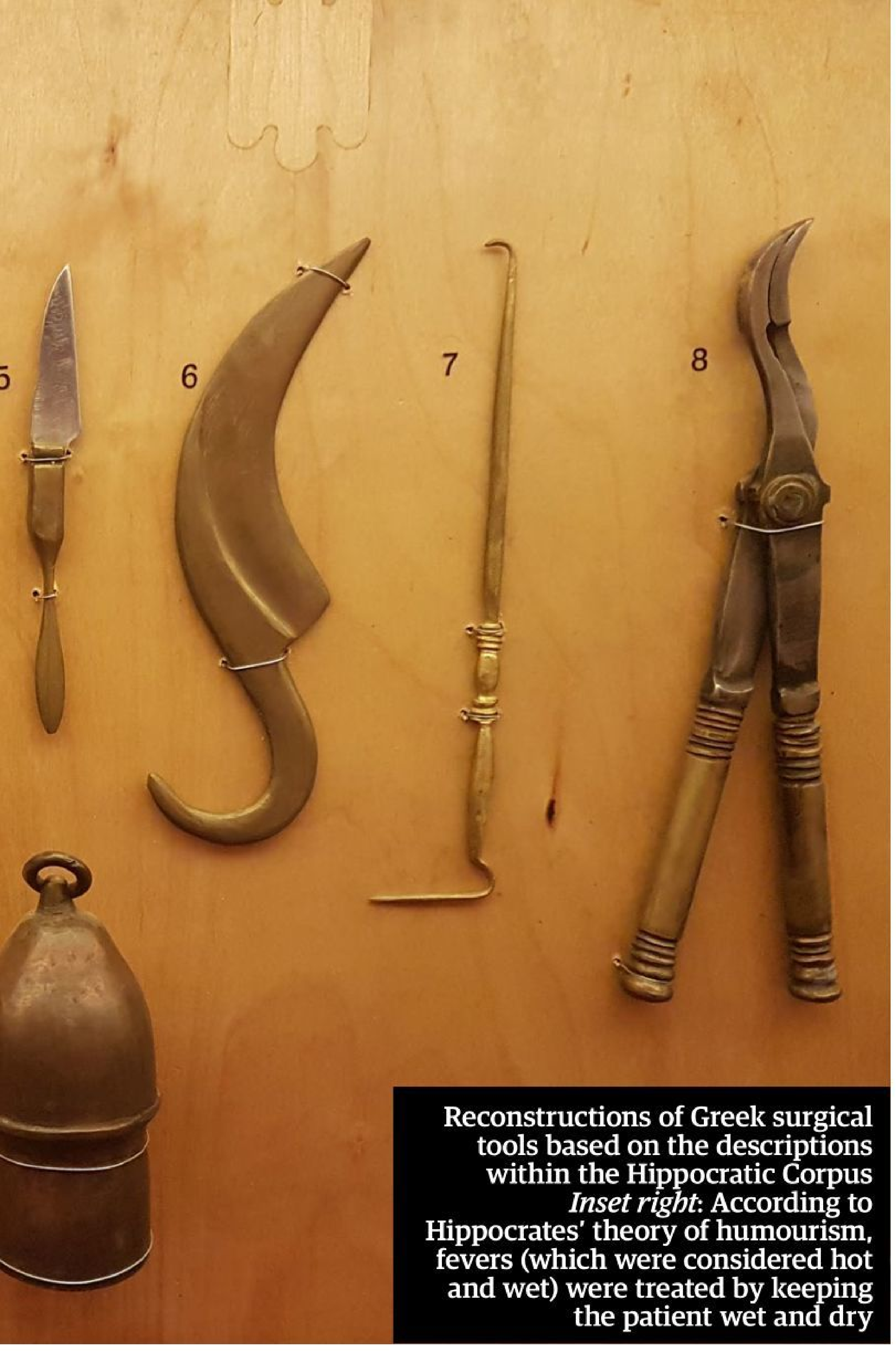
TRAINING AND MEDICAL SCHOOLS

The first medical 'schools' were founded in Greece and in the southern Italian regions of Sicily and Calabria. However, there is no evidence of any physical buildings dedicated to medical training. It is more likely that the term 'school' simply referred to schools of thought formed by an influential medical practitioner and his followers, and therefore was located wherever they happened to gather.

The most famous centres were situated on the island of Kos and on the peninsula of Knidos in Turkey. It's often said that these two schools had rivalling philosophies, with Knidos more focused on the disease and Kos more focused on the patient. Students of the two 'schools' would observe their masters diagnosing and treating diseases.

Meanwhile, the best way to learn surgery was to accompany the Greek army on campaign. But with no formal system of training and with no recognised certificate confirming a physician's right to practice, anyone could become a doctor if they so wished.

The asklepion on Kos is where Hippocrates was probably trained

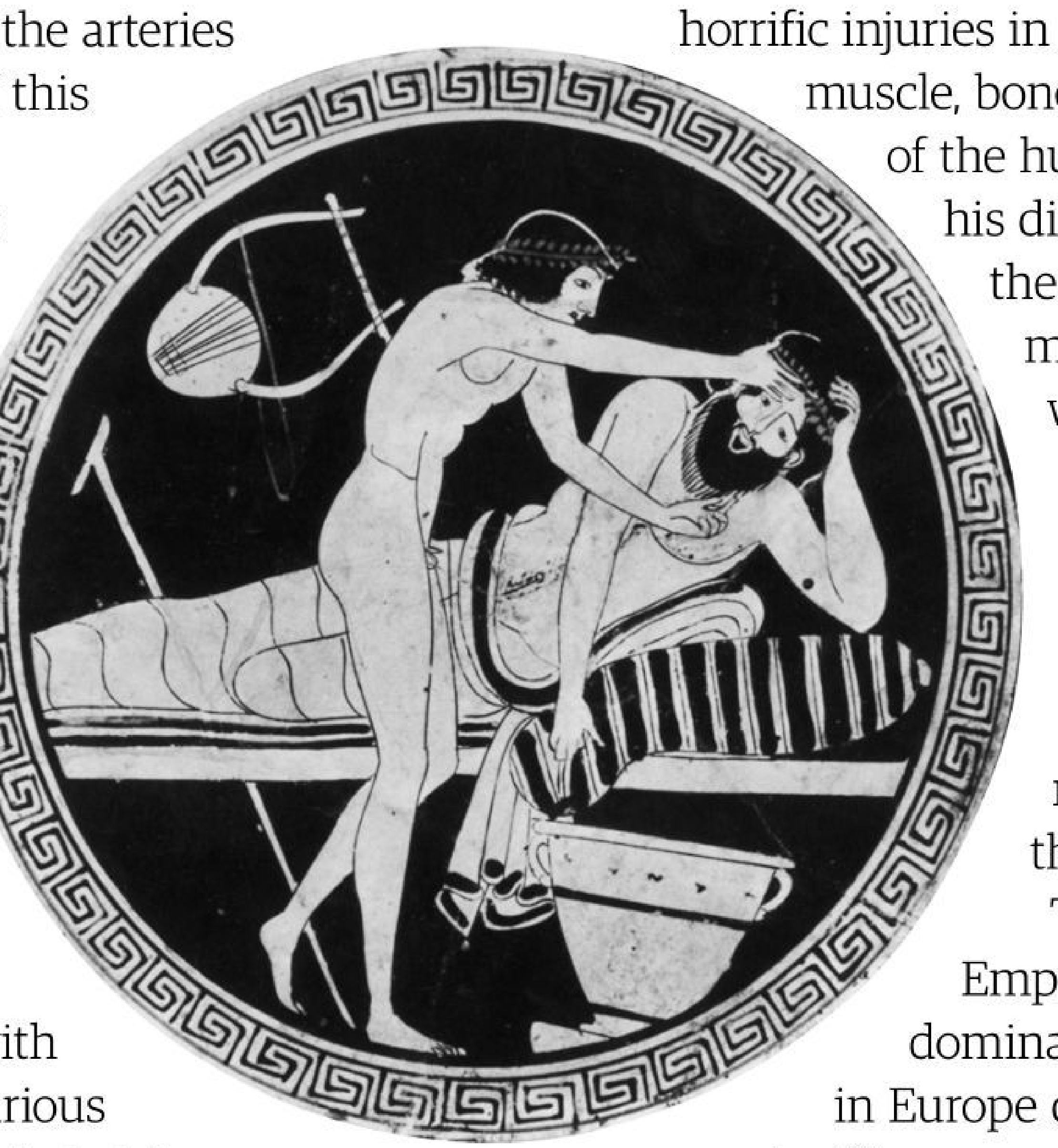


Reconstructions of Greek surgical tools based on the descriptions within the Hippocratic Corpus *Inset right*: According to Hippocrates' theory of humourism, fevers (which were considered hot and wet) were treated by keeping the patient wet and dry

In Greek mythology, Asclepius was a son of Apollo and the god of medicine. The snake, which can be seen entwined around his staff, had long been associated with health due to its ability to shed its skin and regenerate

to experiment on, which he and Erasistratus dissected while still alive.

Thanks to the (albeit involuntary) contributions of these criminals, Erasistratus was the first to link human intelligence with the complexity of the brain's surface compared to those of other animals. Some of his other theories, however, were less accurate. He claimed that the human system of blood vessels was controlled by vacuums, which drew blood across the body. Air, he argued, entered the body and was drawn by the lungs into the heart, where it was then transformed into 'vital' spirit. It was then pumped by the arteries throughout the body. Some of this vital spirit reached the brain, where it was transformed into 'animal' spirit, which would then distributed around the body by the nerves.



Beyond the dissection of criminals, wounded soldiers often provided the most opportunities for learning about human anatomy. Aside from health problems such as malnutrition, dehydration and typhoid, military doctors had to deal with a range of injuries made by various weapons. Treatments often included the use of natural remedies like vinegar or honey. They learned to remove foreign bodies, clean wounds, stop excessive blood loss and set broken bones. However, there is little evidence to suggest that Greek surgeons successfully operated inside the body. Though opium may have been used as an anaesthetic, this was rare, and patients were often simply held down during treatments. This would have made surgery very hard to perform.

The practise of experimenting, observing and recording continued into the Roman era. The 1st-century-CE physician Pedanius Dioscorides – a Greek who was employed in the Roman army – wrote an encyclopaedia of some 600 medical substances, which never went out of publication and formed the basis for the Western pharmacopeia until the 19th century.

Among the greatest of the Greek medics was Galen, born in 129 CE, who eventually settled in Rome and became physician to the emperors. Though human dissection had also been banned in the Roman Empire, Galen was able to learn much about human anatomy through his work at the gladiatorial arena. In dealing with some of the most horrific injuries in history, he could observe muscle, bone and other components of the human body, documenting his discoveries and forwarding the field of ancient Greek medicine. It was he who realised that each hemisphere of the brain affected the opposite side of the body, and he also discovered that severe spinal injuries could result in paralysis below the point of the trauma.

The fall of the Roman Empire and subsequent dominance of the Church in Europe dramatically slowed scientific progress. But Greek medicine continued to be practiced in Byzantium, and the Hippocratic-Galenic tradition spread through the Muslim world. Though their texts reappeared in the Latin West during the Renaissance, the natural healing methods of Greek medicine were gradually abandoned in favour of more synthetic, technological treatments and interventions. But their legacy lives on in their methodology, which is now considered standard practice. And of course, the Greek symbol for healing – the snake-entwined Rod of Asclepius – can be seen on the side of ambulances around the world to this day.

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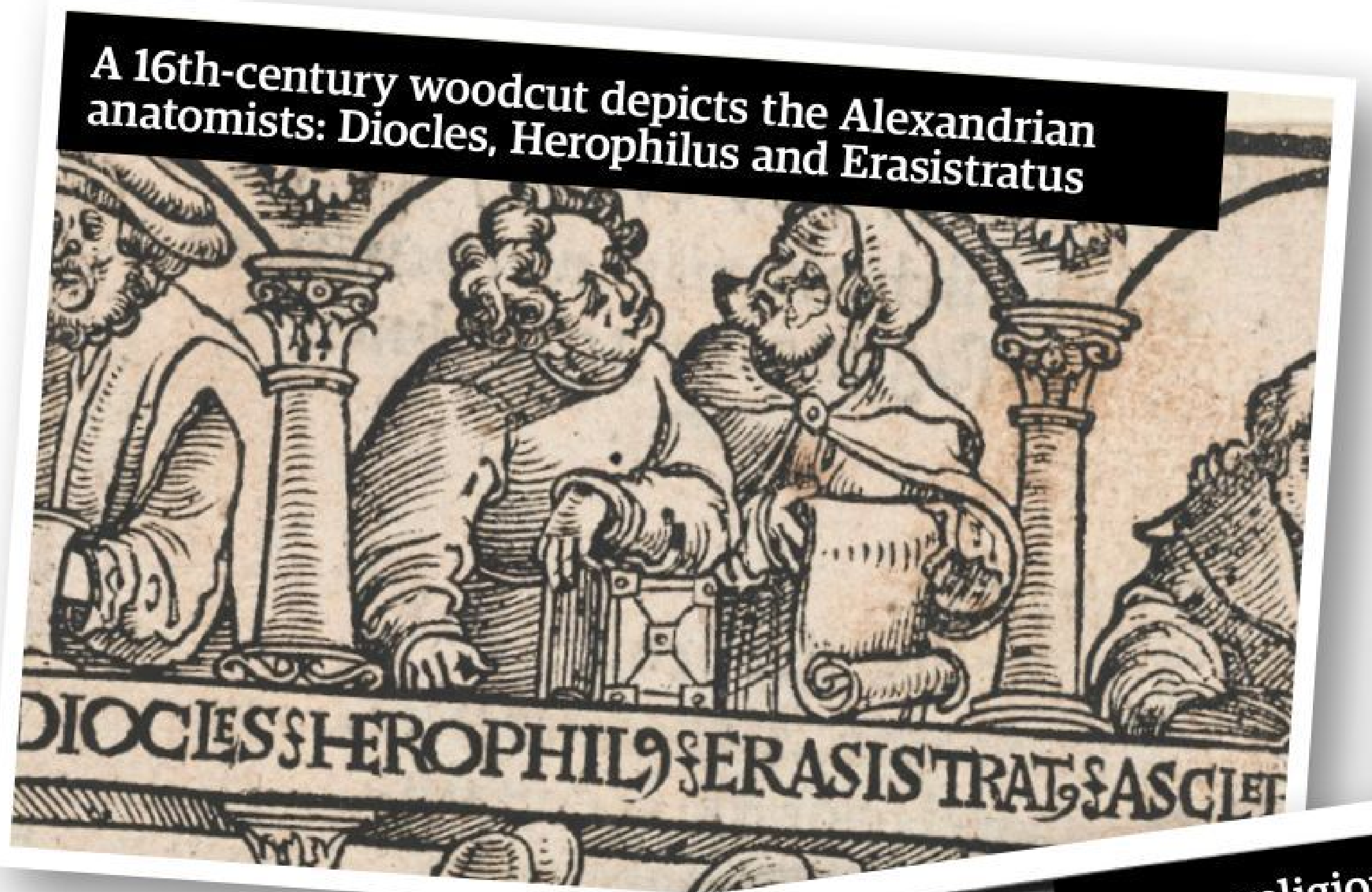
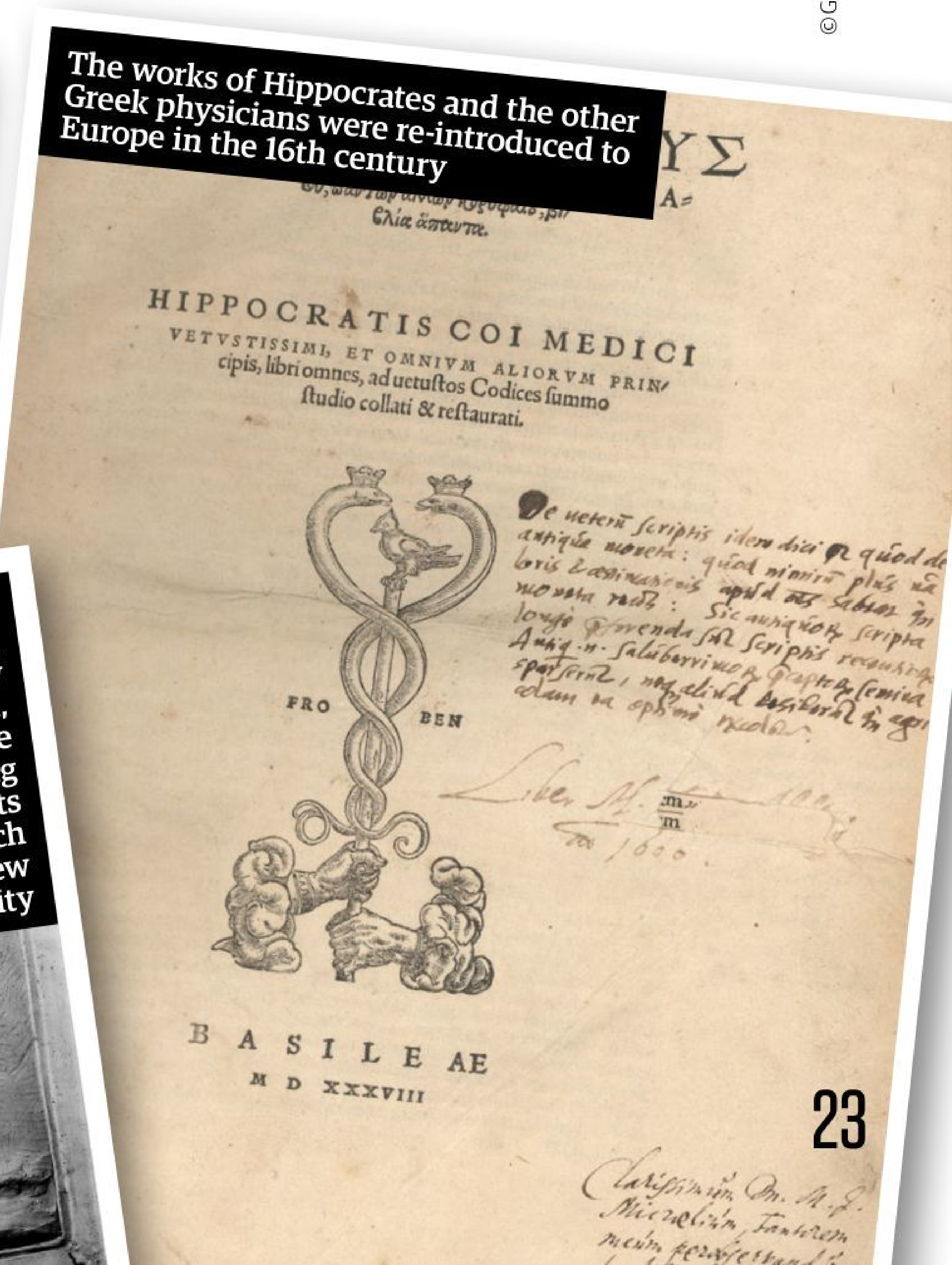
A 16th-century woodcut depicts the Alexandrian anatomists: Diocles, Herophilus and Erasistratus



The works of Hippocrates and the other Greek physicians were re-introduced to Europe in the 16th century



HIPPOCRATIS COI MEDICI
VETVSTISSIMI, ET OMNIVM ALIORVM PRIN-
cipis, libri omnes, ad uetustos Codices summo
studio collati & restaurati.

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Once religion and health had been largely disassociated, the practice of observing patients to reach diagnosis grew in popularity

MEDICINE

FROM GREECE TO ROME

Though the Greek city-states may have been crushed, their scientific knowledge was preserved and practised throughout the Roman Empire

Greek culture infiltrated many aspects of Roman life. The Greeks had been settling in southern Italy and Sicily since the 8th century BCE, so Italian tribes had lived alongside them for centuries. The Roman alphabet, coinage, measures and religion all derived from those of their European neighbours.

In the early days of Rome, as in Ancient Greece, religion and health were inextricable. The worship of the Greek god of medicine Asclepius spread to Italy in the 3rd century BCE, and a healing temple was built in his honour on Tiber Island in Rome. Even with greater understanding of the natural causes of disease, the gods continued to be called upon in cases of severe illness or in times of famine or plague.

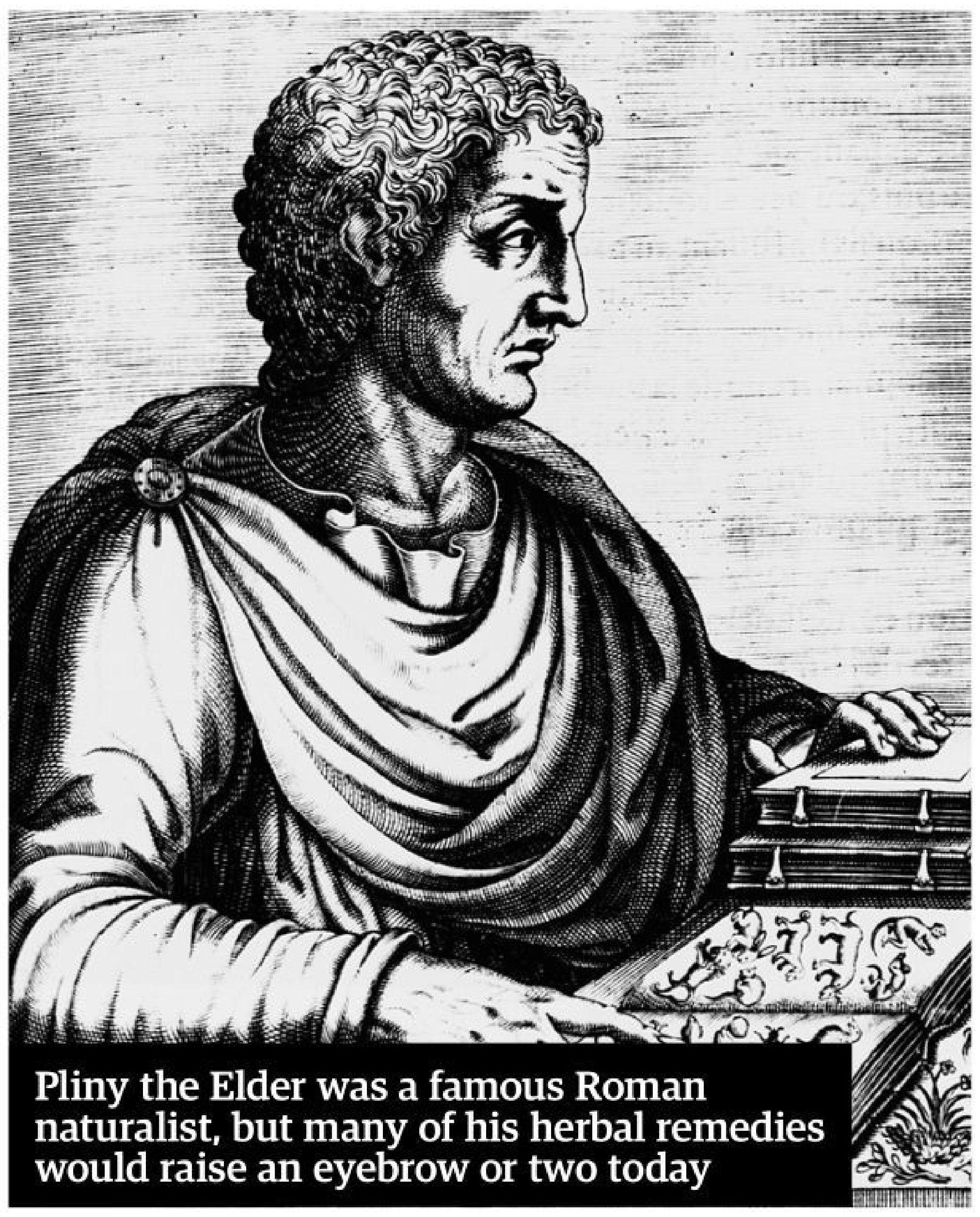
With the conquest of Greece in the 2nd and 1st centuries BCE, many of the great Greek physicians were brought to Rome – either voluntarily or as slaves. As a result, the practice of clinical observation grew, as did recognition of humoral theory. Many Roman cures aimed at rebalancing the bodily fluids, as prescribed by Hippocrates – for example, the use of hot pepper to treat a cold and cool cucumber to treat a fever.

Despite this, much suspicion surrounded Greek medicine and doctors were not held in anywhere near as high regard as they had been before in Greece. Roman naturalist and philosopher

PLINY THE ELDER: MEDIC OR MAGICIAN?

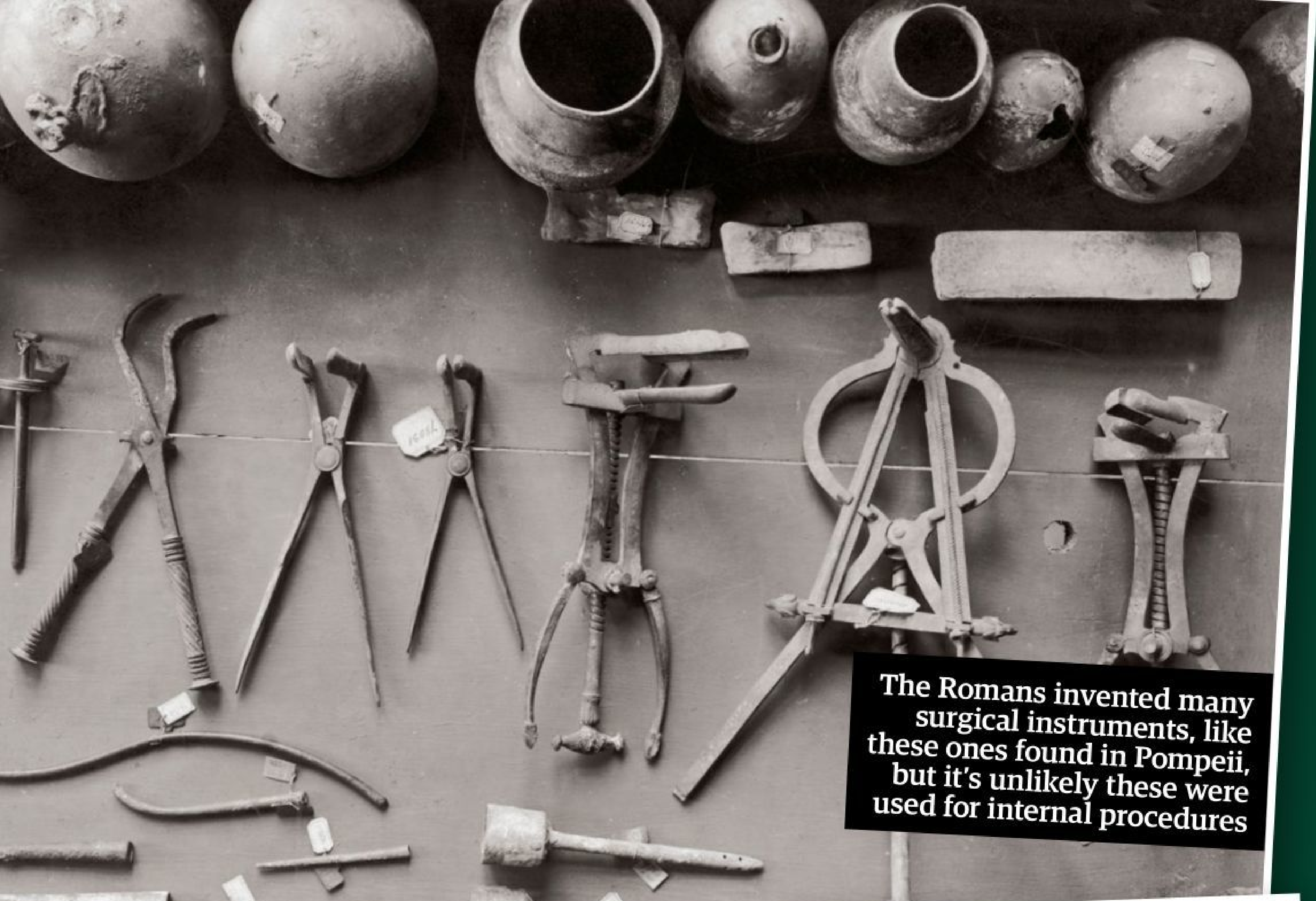
Pliny the Elder was born into a prosperous Roman family in 23 CE. During his lifetime, he dabbled in many professions including law, the military and philosophy, but he is most famous for authoring *Naturalis Historia*. Comprised of 37 books, it covers subjects from cosmology through to geography and zoology. It was in his books on botany that Pliny came closest to making a genuine contribution to science, although today we would struggle to see them as anything more than magic spells.

Pliny listed over 900 things that could be used to cure various ailments, from eggs to earthworms. To treat high sexual desire, for example, he prescribed "a man's urine in which a lizard has been drowned". For toothache, he suggested "the ashes of the head of a dog that has died in a state of madness". And if you were suffering from epilepsy, "a camel's brain, dried and taken in vinegar" was bound to do the trick.

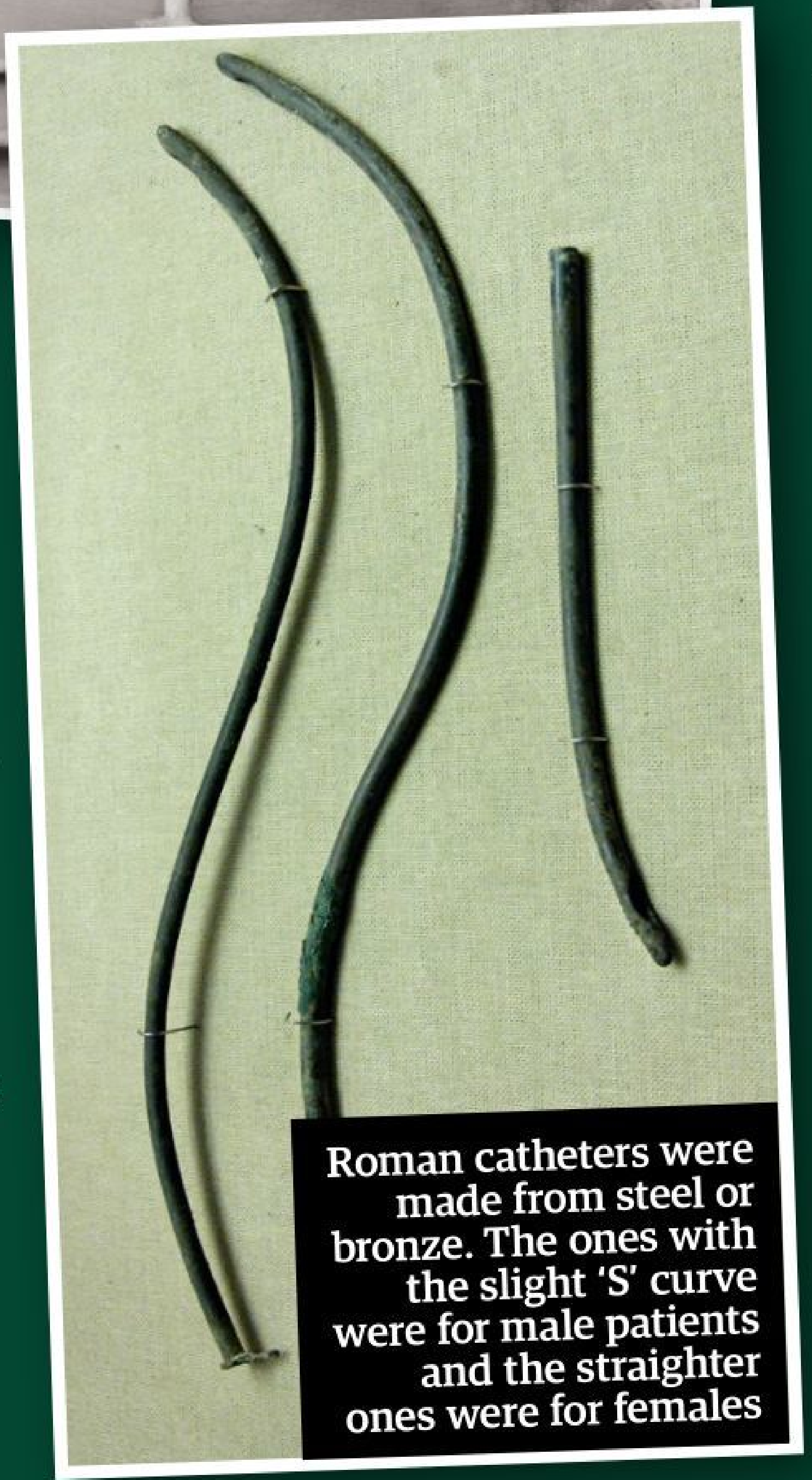


Pliny the Elder was a famous Roman naturalist, but many of his herbal remedies would raise an eyebrow or two today

The Romans were the first to establish a military medical corps – the milites medici



The Romans invented many surgical instruments, like these ones found in Pompeii, but it's unlikely these were used for internal procedures



Roman catheters were made from steel or bronze. The ones with the slight 'S' curve were for male patients and the straighter ones were for females

Pliny the Elder branded the foreign physicians as vain self-publicists, writing: "There is no doubt that all these physicians in their hunt for popularity by means of some new idea, did not hesitate to buy it with our lives. Medicine changes everyday, and we are swept along on the puffs of clever brains of the Greeks… as if thousands of people do not live without physicians."

As the empire expanded, there came a greater desire to foster a fit and healthy population, who would therefore ensure a fit and healthy army. Unlike Ancient Greece, which had been divided into small city-states, the empire was governed by a single ruler who imposed a single system of laws. Wealth flowed in from all four corners, and rather than direct it at philosophy and culture, much of it went into public health projects. The Romans understood that poor hygiene and sub-standard living conditions had a negative impact on wellness, so infrastructure was created that aimed to improve these, including aqueducts, sewers and baths. Over 100 public latrines were installed in Rome, and both these and the streets were cleaned each night by an army of slaves. For the Romans, unlike in Greece, prevention was better than cure.

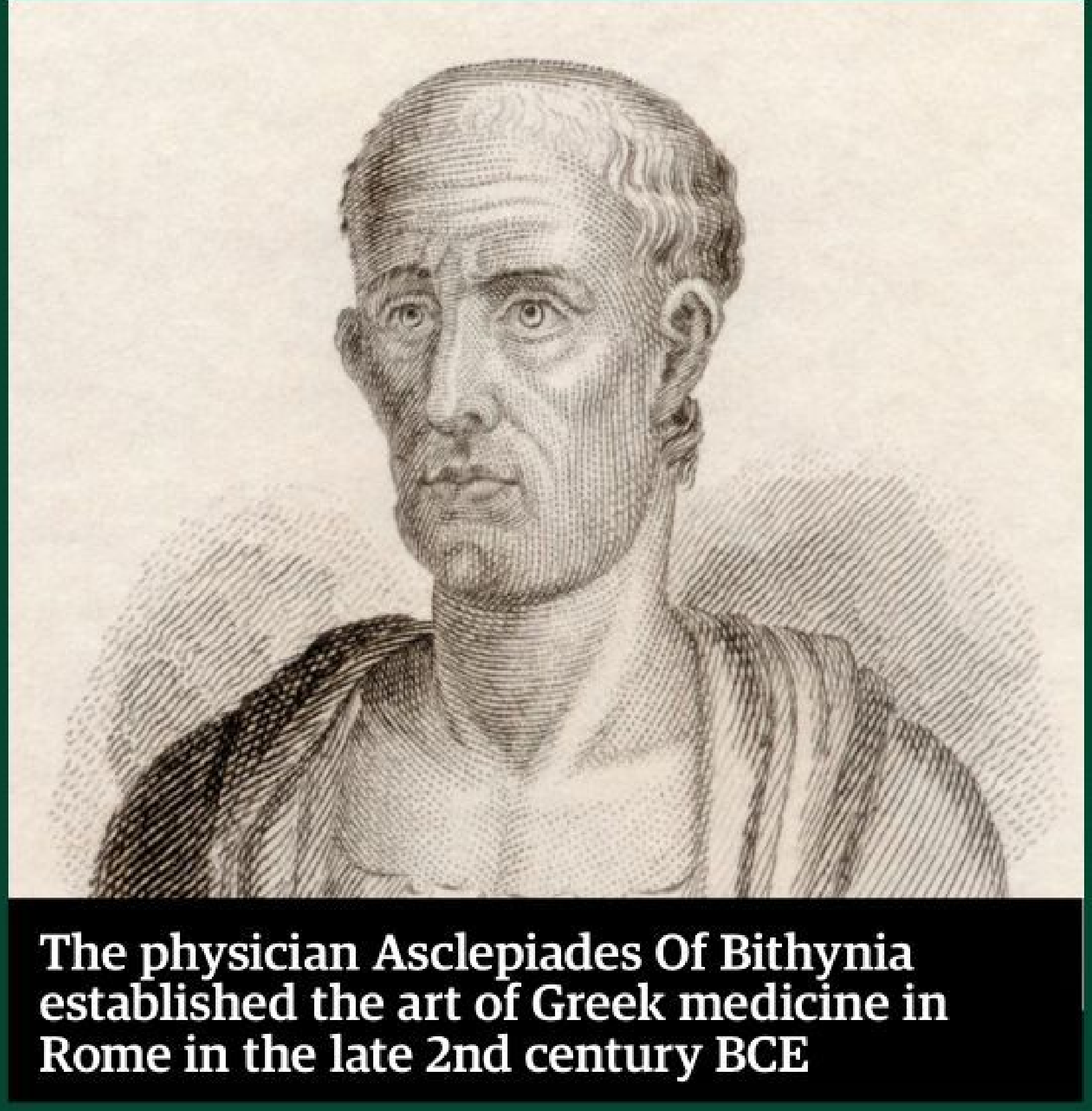
Military medicine flourished. A team of full-time doctors (mostly Greeks) called milites medici accompanied the Roman armies, becoming the world's first medical corps. From around 100 BCE, field hospitals called valetudinarian were built throughout the empire to care for wounded soldiers. Here, basic first aid and external surgery were carried out using a wide range of surgical instruments that had been invented by the Romans. With the dissection of humans forbidden – as in ancient Greece – physicians had to rely on animals to further their understanding of human anatomy. Theories about the workings of the body were therefore often incorrect and internal surgery was rare.

Care was taken to ensure that army camps were set up in 'healthy' areas and away from swamps, which had long been associated with disease. Though the Romans weren't aware that it was in fact the mosquitoes causing what we now call malaria, their suspicions surrounding the swamps were ultimately justified, and many of the ones around Rome were subsequently drained.

The eventual declaration of Christianity as an accepted religion in the Roman Empire drove an expansion of the provision of care. Hospices known as xenodochia were constructed in every cathedral town, initially to shelter pilgrims and messengers, but they were later used to house the disadvantaged, sick and infirm. These eventually developed into the hospitals we know today, staffed by physicians, nurses and orderlies. Facilities included treatment rooms and specialised wards for various diseases.

Despite the advancements in public health, medical science showed little development in the Roman era. The Romans neglected to further develop the Greeks' ideas about the nature of disease, and most medical writers merely produced compilations and translations of ancient Greek sources. Complaints about the lack of expertise of doctors led to wider dissemination of medical knowledge among laymen, and self-help became more common.

When Christianity became the state religion in the 4th century, the Church came to dominate all areas of society, and scientific progress came to a halt. But by preserving Greek practices through documentation and the development of infrastructure, the Romans had paved the way for the rebirth of medicine during the Renaissance.



The physician Asclepiades Of Bithynia established the art of Greek medicine in Rome in the late 2nd century BCE

Asclepiades of Bithynia

A Greek doctor in Rome

Asclepiades of Bithynia was born in 124 BCE in Prusa, Bithynia (modern-day Turkey), and learned the art of medicine in Alexandria. After travelling extensively, he eventually settled in Rome, where he established Greek medicine in the late 2nd century. However, he rejected the ideas of Hippocrates and instead tried to build a new theory of disease, based on the flow of atoms through pores in the body.

Illness, Asclepiades believed, was the result of an obstruction of pores or of an irregular distribution of atoms. His remedies, therefore, aimed at restoring harmony. He argued that fresh air, healthy diet, hydrotherapy, massage and exercise would all solve the problem.

As well as establishing the atomic theory in medicine, he was also famed for his humane treatment of the mentally ill. He ordered that they be freed from confinement and treated them by using occupational therapy, music, wine and exercise. His influence continued until Galen began to practice medicine in Rome in 164 CE.

Unlike in Greece, greater emphasis was put on prevention rather than cure. Infrastructure like public baths helped to improve people's health

The rod of Asclepius – which remains the Western symbol of medicine – can be seen on the walls of Tiber Island, where Rome's first healing temple was built

© Getty Images, Creative Commons; Diego Dels, Joris

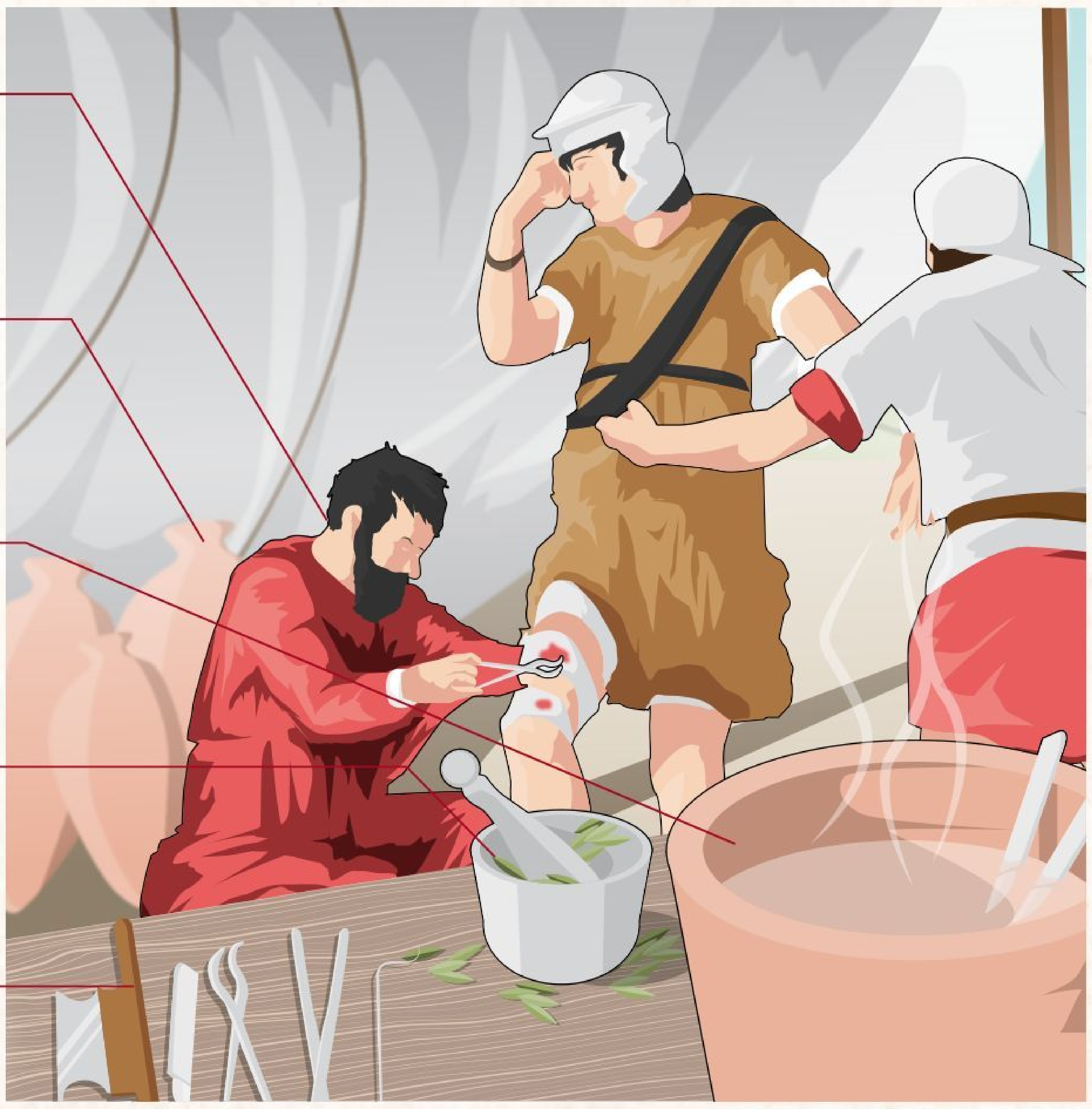
HOW TO

BECOME A ROMAN DOCTOR

A STRONG STOMACH AND A SKILLED HAND ARE REQUIRED TO TREAT THE LEGIONS

ROMAN EMPIRE, C.27 BCE – 476

Roman battlefield medicine was the best in the ancient world. Drawing inspiration from older Greek practices, the Romans introduced their own additions that saved many lives. In everyday Roman life, medicine was a rather private event, with some households retaining staff with medical knowledge. This was in contrast to military medicine, which was practiced publicly. The first emperor, Augustus, established the medical corps to deal with the ailments that might afflict a soldier in the field. These doctors, known as medici, brought cutting-edge expertise to soldiers around the empire, and many of their practices are still used in modern medicine.



Experience
Under Emperor Augustus, Roman Medical Corps were created with specialist knowledge of treating wounds.

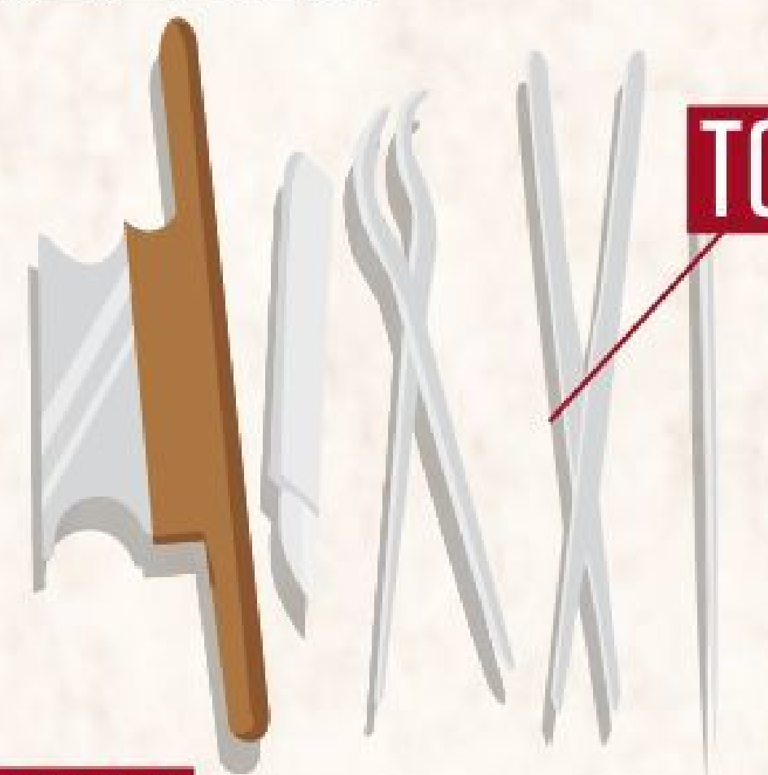
Supplies
It's said that 'an army marches on its stomach', and Roman doctors knew the importance of a healthy diet for soldiers.

Hygiene
Roman doctors used vinegar or boiling water to sterilise their tools, helping to keep wounds free from infection.

Pharmacology
Knowing the medicinal properties of plants was essential. A field hospital would have had a dedicated garden for medicinal herbs.

Instruments
A skilled hand was needed to use the bronze or silver tools like scalpels, forceps, tweezers, lancers and needles.

WHAT YOU'LL NEED...

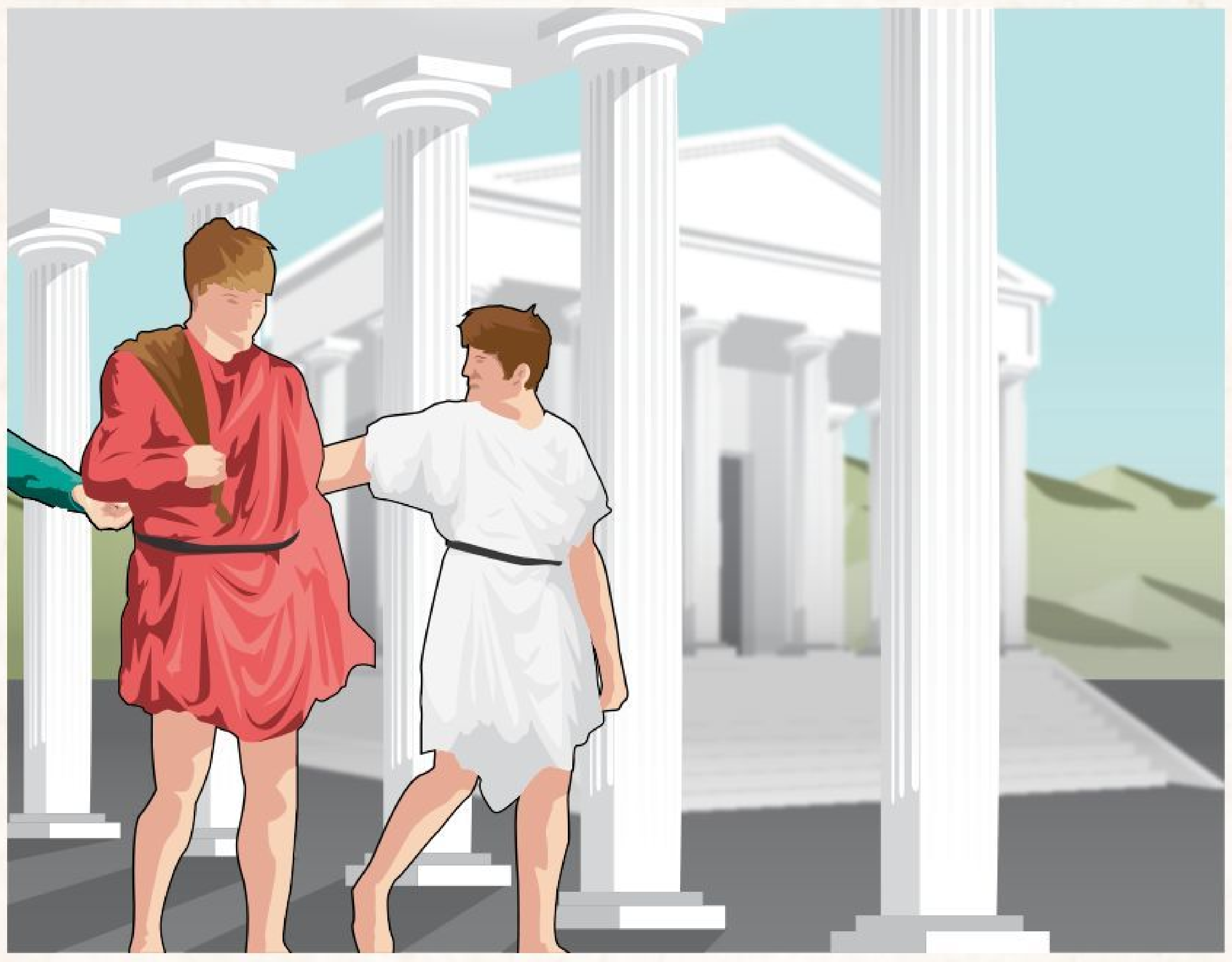

TOOLS

HERBS

LEATHER BIT

LEATHER STRAPS

LINEN BANDAGES



01 Attend school

Starting with Greek texts, you will spend months studying the medical field before going on campaign. With proficiency in cutting, drilling and hacking, the job description might make you sound more like a carpenter than a doctor. When you have a high enough level of skill, you might be able to accept bribes for providing preferential treatment.

02 Pick the right spot

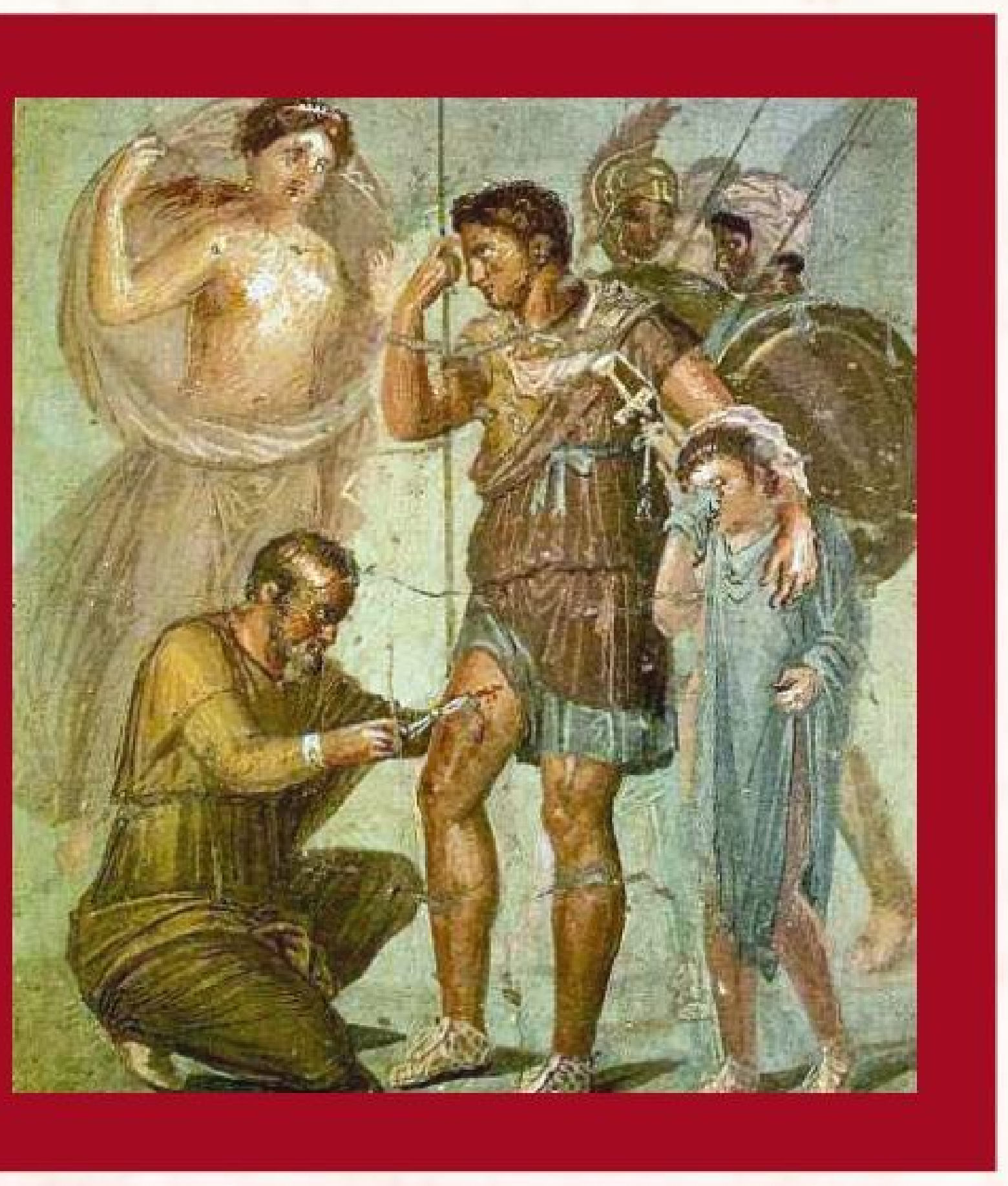
It may seem an unusual job for a doctor, but selecting the placement of the Roman military camp could mean defeat or victory. You must ensure that the latrines (toilets) are dug away from fresh water and make sure other camp conditions are sanitary to greatly reduce the risk of disease. The wounded travel with the army in the baggage train.

How not to... do as the Romans did

While in many ways Roman medical knowledge was far ahead of its time, they would still borrow quack remedies from the Greeks, and create a few of their own. Some practices like blood-letting were common throughout history, and the Romans were known to use this now-abandoned technique.

The Roman medical writer Cornelius Celsus recorded and analysed traditional Greek remedies that would have a modern doctor slapping their forehead. Having a scented steam bath to revitalise the body or using snakes to get rid of troublesome abscesses were just two of his outlandish findings. The strangest is perhaps the cannibalistic ritual of drinking the blood of a dead gladiator in an attempt to cure epilepsy.

Most Romans subscribed to the miasma-style theory that diseases were caused by bad air, as they did not have an understanding of germ theory. Before proper camp hygiene was accepted, illness was rife and could severely hinder a legions' ability to fight. Experience taught the Romans to adapt, although they may not have fully understood why the changes helped.



03 Ready the equipment

In preparation to receive the wounded, you will need to ready your supplies and tools. Plants like St Johns Wort will help to tackle inflammations. While it is not certain that the Romans had an in-depth knowledge of germs, experience taught them the merit of keeping medical instruments clean and sterilised, which helped to limit the risk of infection.

04 Form an orderly queue

When the battle has been fought, the wounded men will come flooding to your hospital tents. You need to decide which men to see first based on the seriousness of their wounds. Use wine and opiates as painkillers, but make sure not give the patient too much as they could faint. These remedies will often just dull the pain rather than get rid of it altogether.

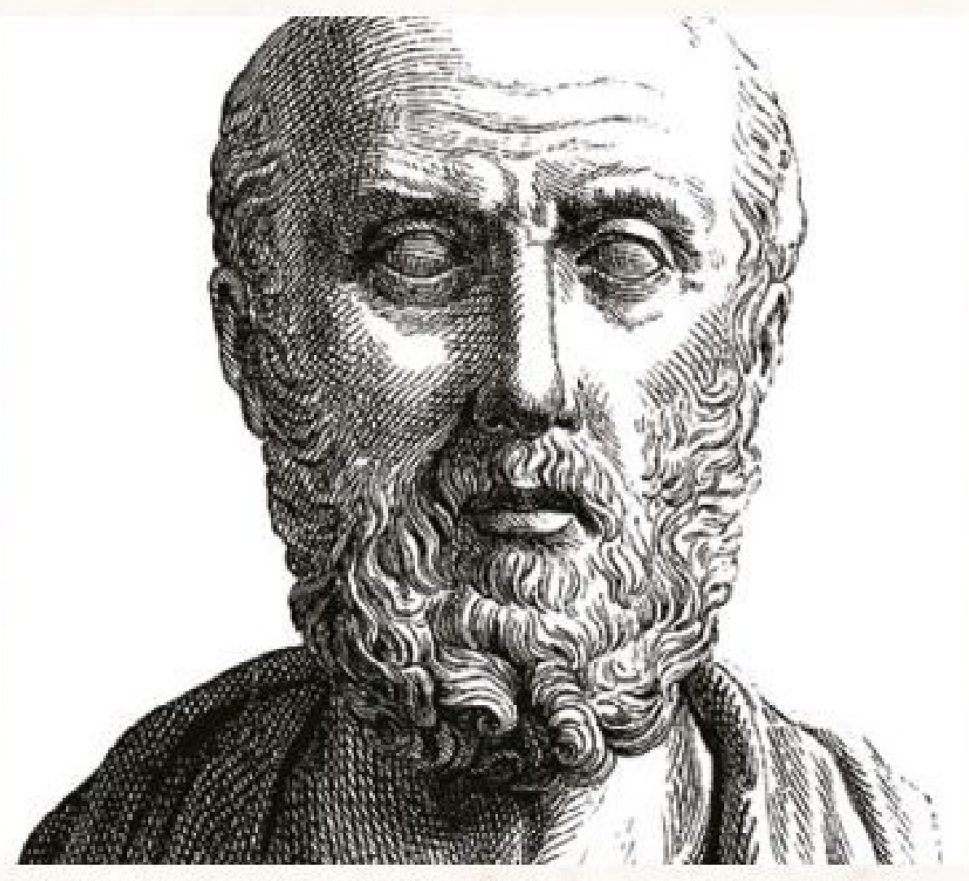
05 Save some lives

While some wounds, like punctures, can be tended to without much harm coming to the patient, others are risky. If you need to amputate, you must restrain the soldier – and try giving him a leather bit to bite down on – before you saw off a limb. Your knowledge of tourniquets and clean dressings should mean this operation won't be fatal.

06 Look after the troops

Wounds need to be checked and cleaned every three to five days to ensure they are healing. As a doctor, you should also look out for the physical health of the men by ensuring they exercise and eat a proper diet. Your knowledge of the kind of balanced diet the troops need on campaign will see supplies like corn, cheese, wine, fresh fruit and vegetables on the menu.

4 FAMOUS... ANCIENT DOCTORS



HIPPOCRATES

C.460-C.370 BCE

The Ancient Greek understood the importance of battlefield experience: "He who desires to practice surgery must go to war."

AULUS CORNELIUS CELSUS C.25 BCE – C.50 CE

The author of an expansive medical manual, Celsus outlines many practices such as how to amputate and apply a tourniquet.

ARCHAGATHUS OF SPARTA 3RD CENTURY BCE

Archagathus is credited with bringing Greek medical practices to Rome in 219 BCE. He specialised in healing battlefield wounds.

PLINY THE ELDER

23-79 CE

Pliny did not trust doctors and criticised their high fees. He preferred traditional medicine.

© Ed Crooks, Getty Images

DAY IN THE LIFE

AN APOTHECARY

MIXING POTIONS AND TREATING CUSTOMERS WITH AN APOTHECARY

LONDON, CIRCA 1485-1714

In the smoky alleyways of towns and villages across England, exotic smells and strange sights could be found in the rooms of the apothecary's shop. It was a place where commoner and nobleman alike could get advice on specific ailments, with apothecary apprentices mixing strange ingredients into huge cauldrons.

The apothecaries were sought after by the rich and powerful and every king and queen during this period had a master apothecary known as the serjeant of the confectionery. While this position heralded great rewards, the work of an apothecary was often far from glamorous and often courted great risk.

STAR-GAZING

A master apothecary would always rise early in order to gaze at the stars and ascertain how they might affect the illnesses he would be treating during the course of the day. Star alignment was said to affect the nature and seriousness of illnesses, so noting down positions of specific stars was vital to a patient's health.

CONCOCTING

Morning tasks were taken up with the concoction of medications at the apothecary's shop and orders often came from noblemen who had the misfortune of catching venereal disease. While this illness could be cured by an unpleasant procedure involving a tube going through a sensitive area, courtesy of a barber-surgeon, many gentlemen opted for medication. The apothecary mixes garden snails, earworms, ground ivy and aniseed together into a thick paste and orders an apprentice to take it over to the nobleman's lodgings.

Garden snails were just one of the ingredients used to alleviate STIs

APPOINTMENTS

A royal messenger appears and claims that the apothecary must attend upon his majesty immediately. As a yeoman apothecary to the royal household, he is often asked to help his majesty with specific problems. While dealing with the monarch was often a terrifying experience, the monetary rewards often outweighed the abuse.

> "Orders often came from noblemen who had the misfortune of catching venereal disease"

How do we know this?

The story of royal apothecaries has been recounted in a number of general texts that deal with the Tudor and Stuart periods. The physical health of the monarchs of this period, especially Henry VIII and Elizabeth I, who both survived into old age, has long been a subject of fascination for historians. The important role apothecaries and physicians played during the 16th and 17th centuries offers a fascinating insight into how the Tudor-Stuart mind dealt with illnesses and death. Specific works on Tudor apothecaries can be found on the internet including *Royal Apothecaries of the Tudor Period*, which is available to download for free from the Cambridge University Journals website.

ROYAL APOTHECARIES OF THE TUDOR PERIOD

by

LESLIE G. MATTHEWS

ROYAL VISIT

The apothecary approaches the king with apprehension but this time he gets off lightly – his majesty simply wants advice about pain and puss seeping from an old wound and he appears to be in a good mood. The apothecary recommends a poultice to draw out the puss and sweet-smelling rose water to ward off the bad humours that are causing the pain. The four humours were key to Renaissance thinking behind human health and consisted chiefly of black bile, yellow bile, phlegm and blood. The balance and condition of these elements were often used by apothecaries to diagnose illness.

CUSTOMER CARE

As the apothecary leaves the palace he is quickly collared by one of the royal physicians. His majesty wishes to take his bi-annual bath this afternoon and requires the apothecary to scent it appropriately. The apothecary gulps and prays his majesty's good mood holds, then turns to leave, as he will need to gather the very best ingredients for this task.

BUYING INGREDIENTS

The apothecary heads back to the street his shop is on and begins to take rent from his properties. Like many of his fellow practitioners, he uses this income to pay for exotic medicines, many of which come from the Middle East and are incredibly expensive to obtain as a result. His next patient is royalty, so the apothecary puts up with the extortionate prices to get the best very ingredients that money can buy.

SWEET SCENTS

Back at the palace, the king's leg is causing him considerable pain and he is now in a fearfully bad mood. The apothecary convinces him to bathe in sweet scents, as this may temper the bad humours afflicting his leg. The king reluctantly agrees and slips into a bath containing herbs, musks and an ingredient known as civet, a substance sourced from the secretions of civet cats from Africa.

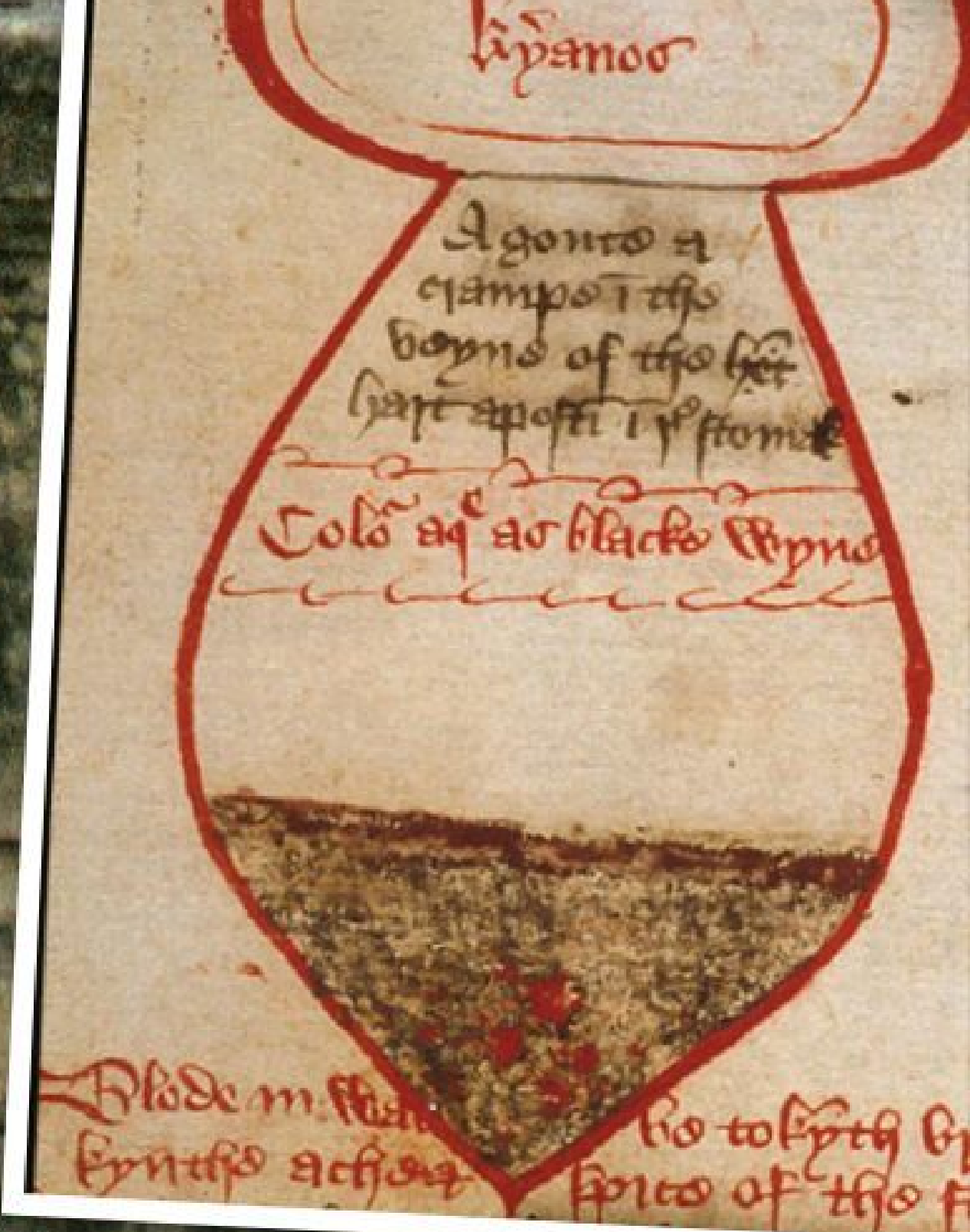
STAFFING

The apothecary finally returns to his shop for the day and immediately is forced to reprimand one of his apprentices. The apprentice was trying to seek employment elsewhere, even though he was already bound to the apothecary. He is now kneeling before the apothecary begging for forgiveness, but is ordered out of the shop by his master – an apothecary could ill-afford disloyal employees. With that bit of unpleasantness over, he turns in for the night.

Only the very best ingredients were reserved for royalty

© Dreamstime, Getty Images, SPL

The University of Montpellier in France was established in 1289 and now includes the world's longest-running active medical school



MEDICINE IN THE MIDDLE AGES

The diagnosis and treatment of illness and injury progressed slowly in the 1,000 years between the start of the Dark Ages and the Renaissance

The Middle Ages is often seen as a period when human progress ground to a halt. The term 'Dark Ages', coupled with popular perceptions of the Black Death and of Medieval life drawn from literary adventures inspired by the period, creates the impression of a time when many people lived in squalor, disease was rampant, and there was a massive divide between the haves and have-nots. Ignorance and superstition were also rife, and medicine, in particular, is often characterised as, at best, primitive and, at worst, barbaric.

Historical records do suggest that medical practices throughout the Early Middle Ages (which lasted from around the late 5th century to the 9th century) were largely driven by superstition and a religious doctrine that leant heavily on classical Greek texts. Yet, during the Late Middle Ages, (from the 14th to the 16th centuries CE) rational ideas about disease and human anatomy gained much traction through the influence of the Arab world and through the creation of the first European medical schools.

Some of the most common illnesses in the Middle Ages were dysentery, typhoid fever and cholera

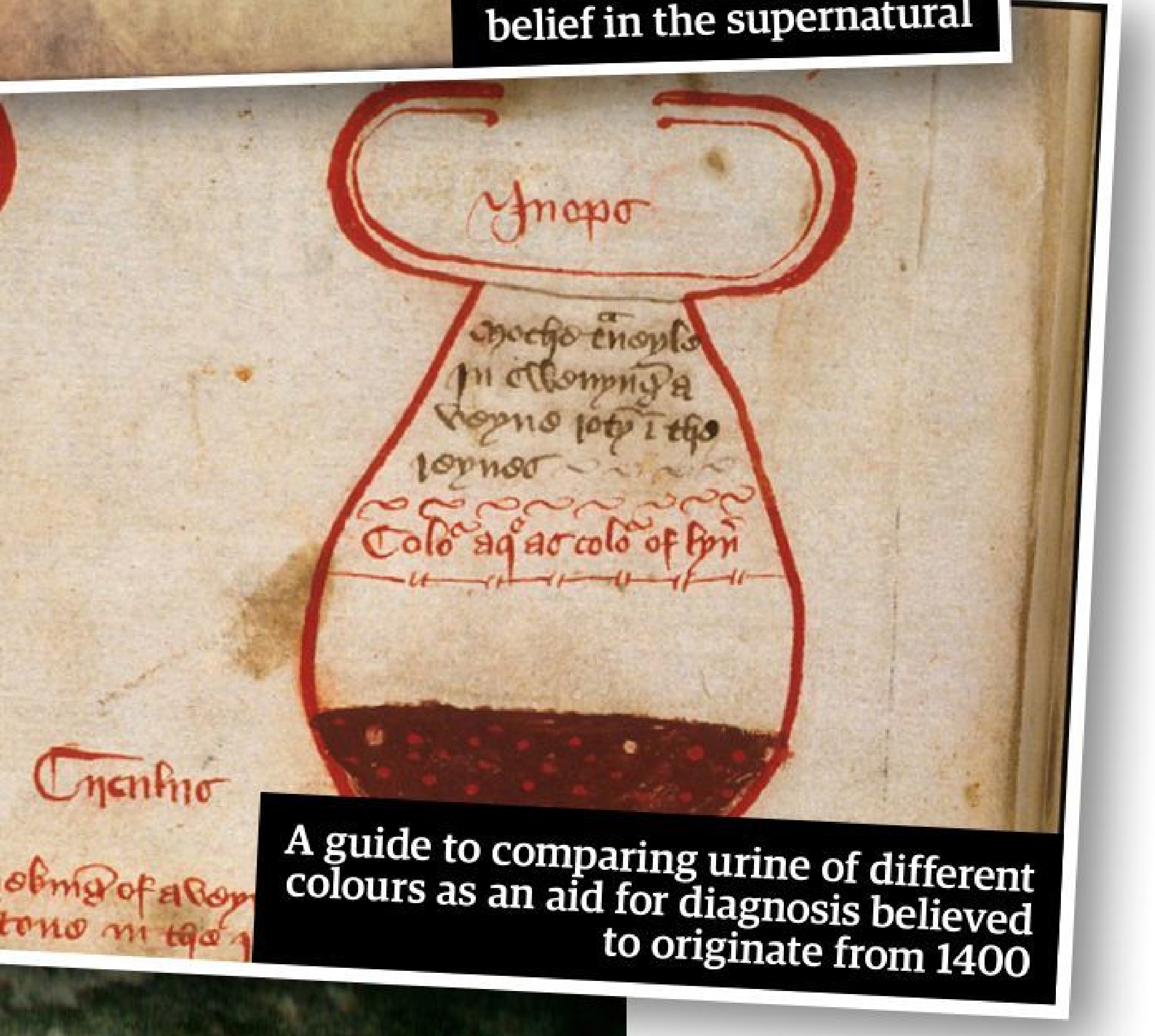
The Middle Ages got its reputation for stagnation by virtue of coming after the fall of the Roman Empire and before the Renaissance. The collapse of Rome left Europe with no overarching authority so the Roman Catholic church was able to establish widespread control. Catholic doctrine was enforced as the only legitimate source of knowledge about the material world, including medicine.

To a degree, this development suppressed the advancement of medical knowledge as clergy expounded the notion that illnesses were God's punishment for sinners and a cure could only be found through prayer, confession and repentance.

Sufferers sometimes took the last of these to extremes and inflicted more discomfort on their bodies by hitting, or flagellating, themselves with a whip or a stick. Clearly, this would have been ineffective against real physical and mental illnesses, although the exertion may have relieved anxiety induced by a guilty conscience.

Ironically, although Catholic doctrine held that everything was the work of God, most medical practices were rooted in Greek philosopher Empedocles' theory of the four essential elements of earth, fire, air and water. This was coupled with the notion of four humours, or vital fluids, namely yellow bile, phlegm, black bile and blood, which Hippocrates and Galen helped to popularise. The combination of these ideas appealed to Catholic authorities because it was

This medical diagram from a 15th-century guide book for barber-surgeons hints at the widespread belief in the supernatural



A guide to comparing urine of different colours as an aid for diagnosis believed to originate from 1400

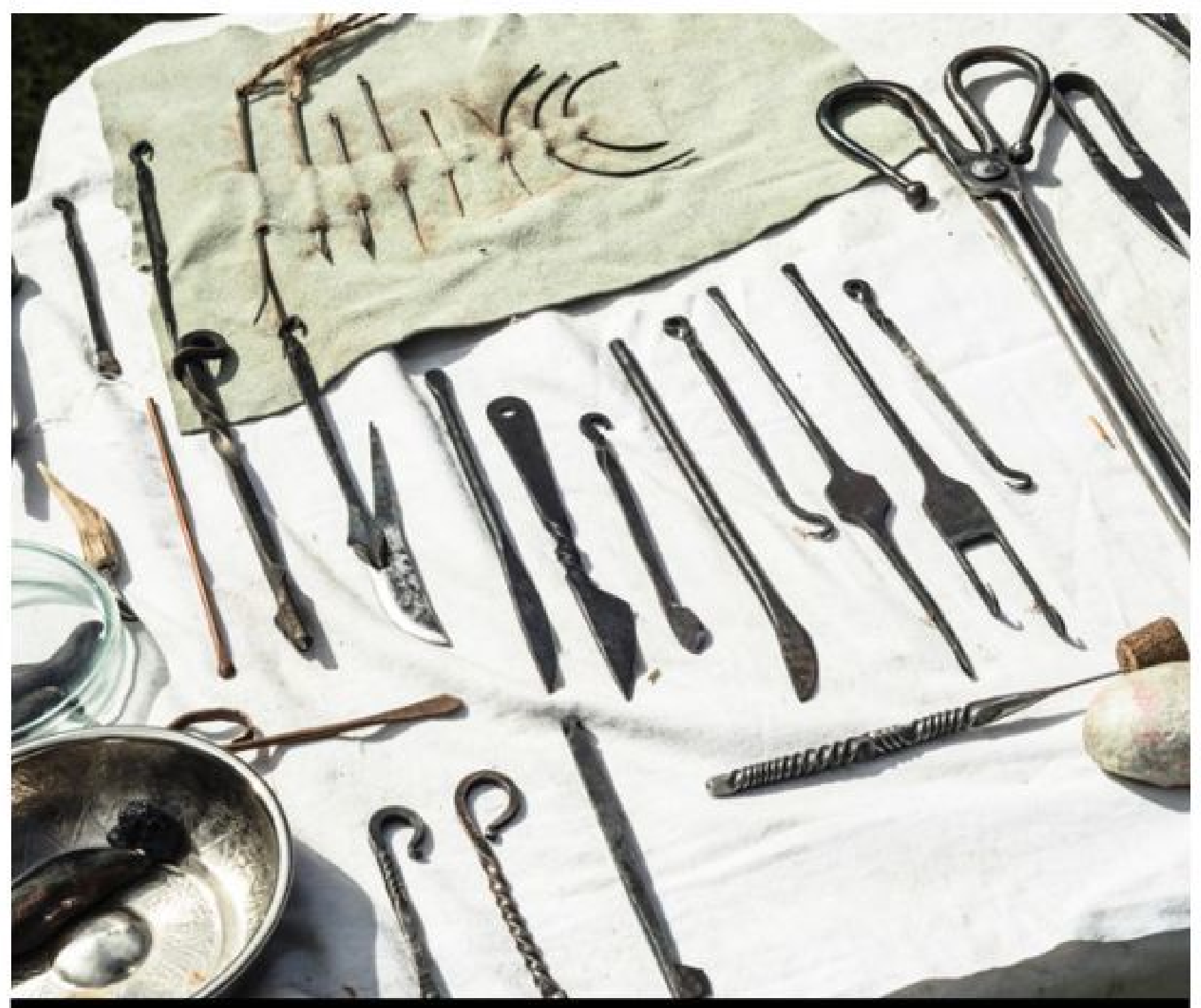
The Nur al-Din Bimaristan, or Islamic hospital, was built in Damascus, Syria, in 1153 and is now a museum

Surgery in the Dark Ages

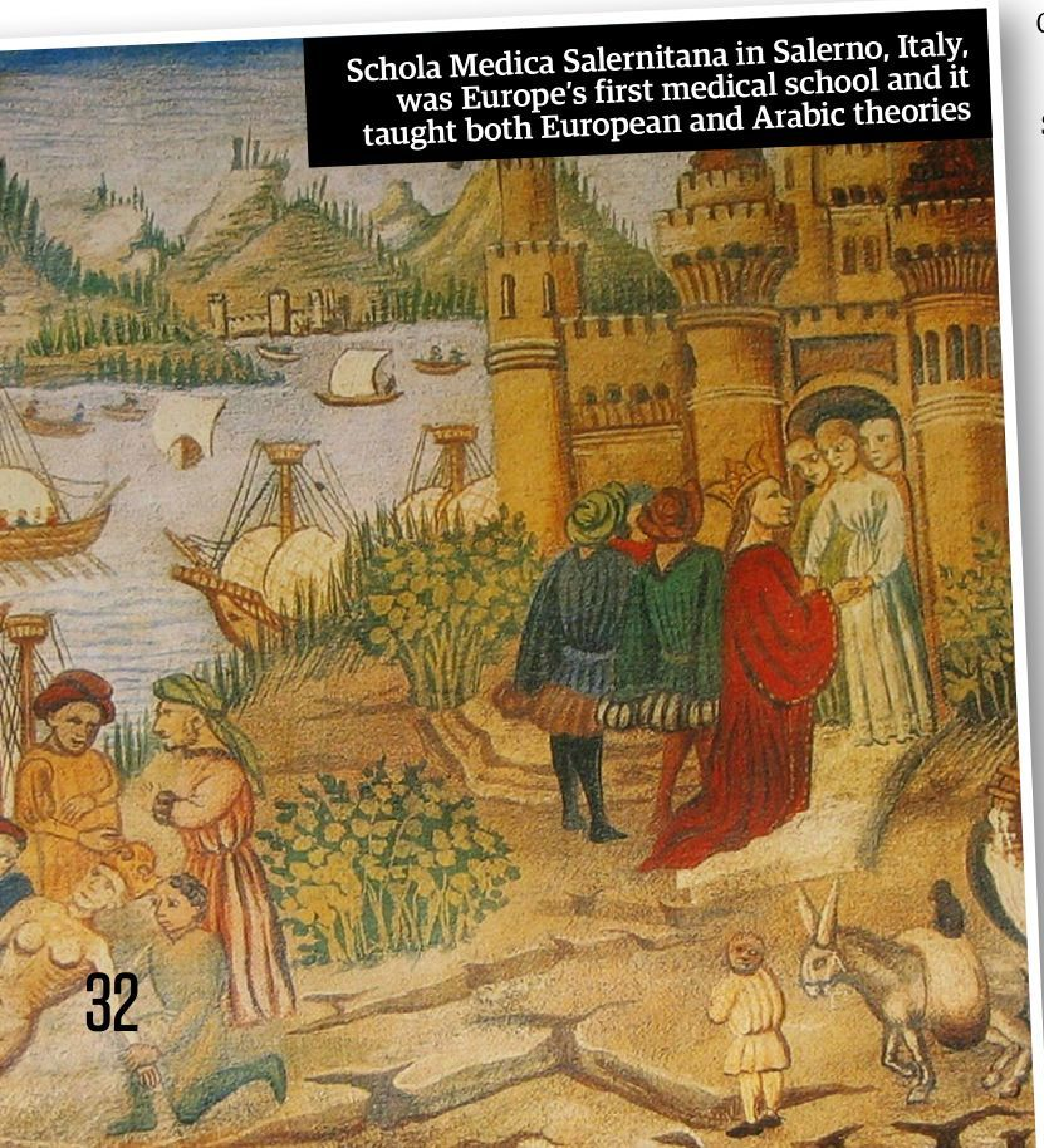
Today's surgeons are highly respected medical professionals but in the Early Middle Ages they were considered inferior to other medical practitioners. Medieval surgery was gruesome and the chances of surviving any serious procedure were slim.

Medieval surgical techniques were influenced by the writings of Greek physicians such as Hippocrates and Galen. Operations were commonly performed in monasteries where monks prepared plant-based anaesthetics using ingredients like mandrake root and opium. Wine was used as an antiseptic but post-operation infection rates were high. The procedures were usually performed by self-taught surgeons or barber-surgeons and they were often on soldiers who had been injured in battle.

From the 11th century onwards, surgery advanced thanks to the translation of Arab texts into Latin. This elevated the status of surgeons in the late Middle Ages, but they still struggled to get academic recognition for their profession. The new medical schools did not initially promote surgery, perhaps because dissecting human bodies was banned by the Catholic Church. Once expertise from the Arab world and a loosening of the Church's prohibition allowed knowledge of human anatomy to progress in the Late Middle Ages, however, surgeons were able to take the first steps towards securing the status they now have.



Medieval surgical instruments looked more like the toys of a sadistic torturer than the tools of a life-saving surgeon



Schola Medica Salernitana in Salerno, Italy, was Europe's first medical school and it taught both European and Arabic theories

already well-established, and it suggested a vital force analogous to a powerful single deity.

Since good health was believed to be the reward for keeping the four humours in balance, it made sense for medical practitioners at the time to suppose they could manipulate bodily fluids to effect cures. One way of doing this was by bloodletting, which was one of the most common medical practices in the Middle Ages. Where surgeons believed that only a small amount of blood had to be removed from the body, they would use leeches. More severe 'imbalances', however, might require cutting the patient with blades that were doubtless poorly sanitised. Hence, bloodletting was just as likely to cause an infection as to cure one, not least because the practice of suturing wounds didn't develop until later on.

Bloodletting was often carried out by barber-surgeons who, as the term suggests, were adept at cutting both hair and flesh. Their proficiency with sharp blades earned them legitimacy as medical practitioners across Europe and they could be asked to perform operations in monasteries and on the battlefield. In the most extreme cases, a surgeon might have to amputate a limb. Given the absence of powerful anaesthetics and antiseptics, however, this procedure wasn't likely to end well for the injured party.

Another bodily fluid that was important in the treatment of illness in Medieval times was urine, although it was used for diagnosis rather than as a treatment. A physician's medical kit included charts that related the colour of a urine sample to a range of conditions. Comparison of the sample to these charts would form the basis of the diagnosis and the treatment. Physicians were trained in this widespread practice as well as other methods of inspecting a patient's outwardly obvious vital signs, such as their breathing.

Yet another irony in a society dominated by a religious order was that treatment of illness in the Middle Ages relied heavily on astrology. The practice is frowned upon by the Catholic Church because it suggests that the universe is

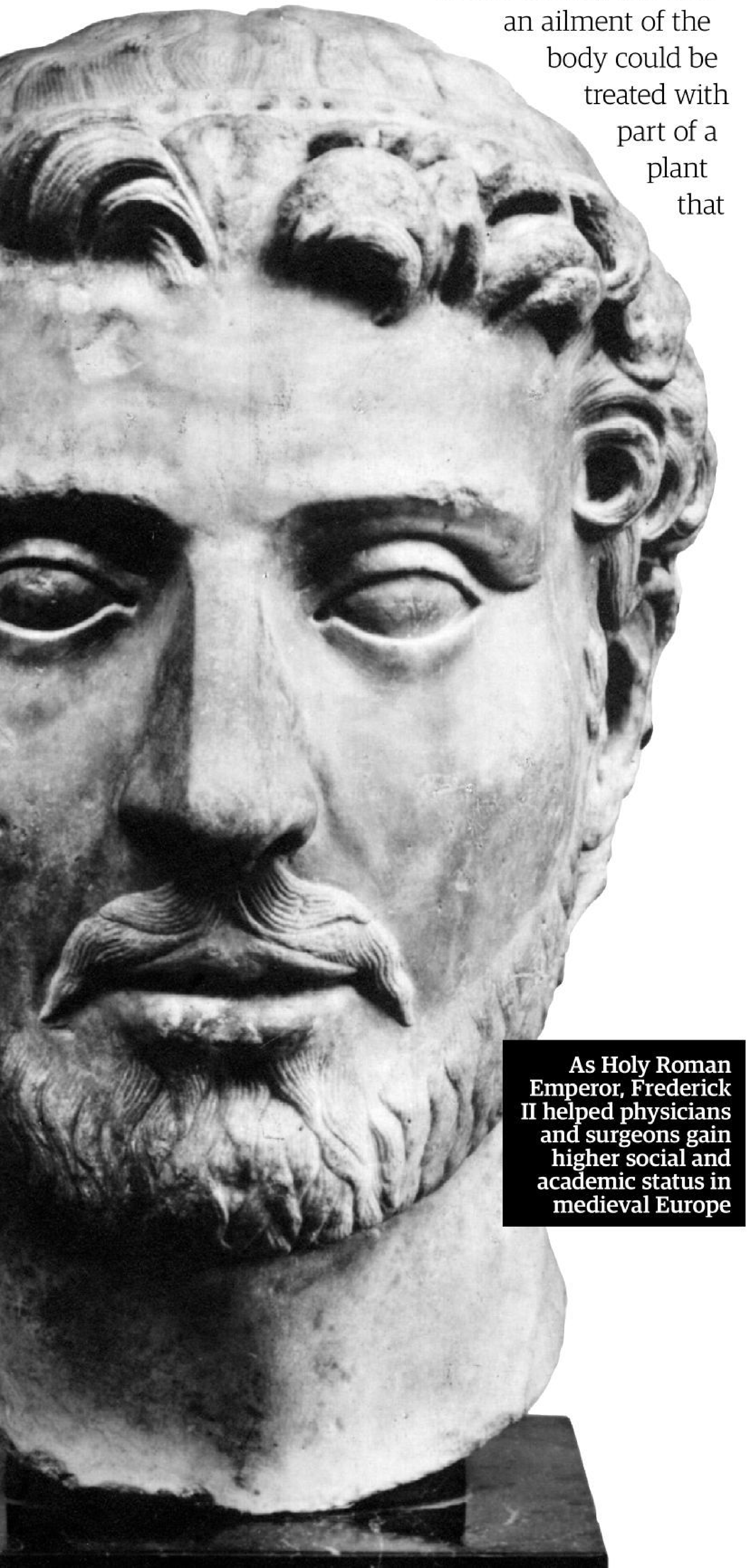
The Black Death is estimated to have killed between 30 and 60 per cent of Europe's total population

> "Their proficiency with sharp blades earned them legitimacy as medical practitioners across Europe and they could be asked to perform operations"

Medieval dentistry wasn't as risky as invasive surgery but without freezing techniques it was probably often painful

influenced by a force other than God. However, in Medieval times, the alignment of the moon and planets was thought to hold sway over human health because of the four elements. Accordingly, the proper timing of administering treatments such as bloodletting was determined by consulting astrological charts.

Other Greek medical principles that were used in the Middle Ages includes the doctrine of signatures. The basis of this approach was based on the assumption that an ailment of the body could be treated with part of a plant that resembled the afflicted organ in some way. Practitioners could draw on the limited knowledge about internal anatomy obtained through the dissection of human bodies by Galen and others. Even so, the doctrine of signatures relied on subjective interpretation of what represented good analogues for body parts and was therefore unlikely to have eased many ailments.



As Holy Roman Emperor, Frederick II helped physicians and surgeons gain higher social and academic status in medieval Europe

Aside from their role in this, plants thought to have medicinal properties were administered to the sick at monasteries. As part of their monastic duties, monks maintained gardens and were charged with the responsibility of experimenting on herbs and spices as well as attempting to heal the sick by appealing to God. Hence, monasteries were essentially Medieval hospitals where the afflicted could seek both absolution and earthly cures. Flowers and other scented parts of plants were also used in cases where it was believed that smells and vapour had curative properties.

In their libraries, monks could refer to historical texts when performing practical rather than religious treatments. Outside of this, however, there were few places prospective physicians and surgeons could learn about medicine and the body until the first true medical schools opened about halfway through the Middle Ages. Credited with being the first such school in Europe, Schola Medica Salernitana, or Salerno Medical School, opened in the 9th century and had a curriculum based on works from both ancient Greece and the Islamic world. Its medical diploma was officially ratified by Holy Roman Emperor Frederick II in 1231 and it remained operational until the 19th century. The University of Montpellier in France also established a medical programme late in the 13th century and students still train there today.

As products of their time, these institutions initially didn't teach or research science-based medicine. Had they done so, they might have helped to contain the ravages of the Black Death, which decimated the populations of Asia and Europe in the mid-1300s. Although this apocalyptic epidemic wasn't the only case of a virulent contagion spreading across Europe in the Middle Ages, it was easily the worst, killing an estimated 60% of the continent's population. The bacteria that caused this plague is believed to have arrived on the continent at the port of Messina on trading ships from the Middle East. The story goes that the first boats carrying infected crews docked at the port with most of those on board already dead. The disease then jumped ship before the boats could be put back out to sea.

Although the blame for the spread of the Black Death has been placed on rats and rat fleas, it could also be contracted by direct contact with a sufferer or exposure to the coughing and sneezing that made the early stages of infection resemble a flu or the common cold. Hence, it would have spread easily in the cramped, unsanitary conditions in which many common people lived.

While the relatively primitive state of Medieval medical knowledge meant that institutions were powerless to prevent the spread of the plague, there were important strides in the Late Middle Ages compared with where it had been a few centuries earlier. Because theories that we now know to be wrong were still prevalent, treatment methods hadn't fully emerged from the Dark Ages. Yet, the creation of medical schools represented some of the earliest attempts to make medicine into an academic discipline and challenged the Catholic Church's influence over medical practice.

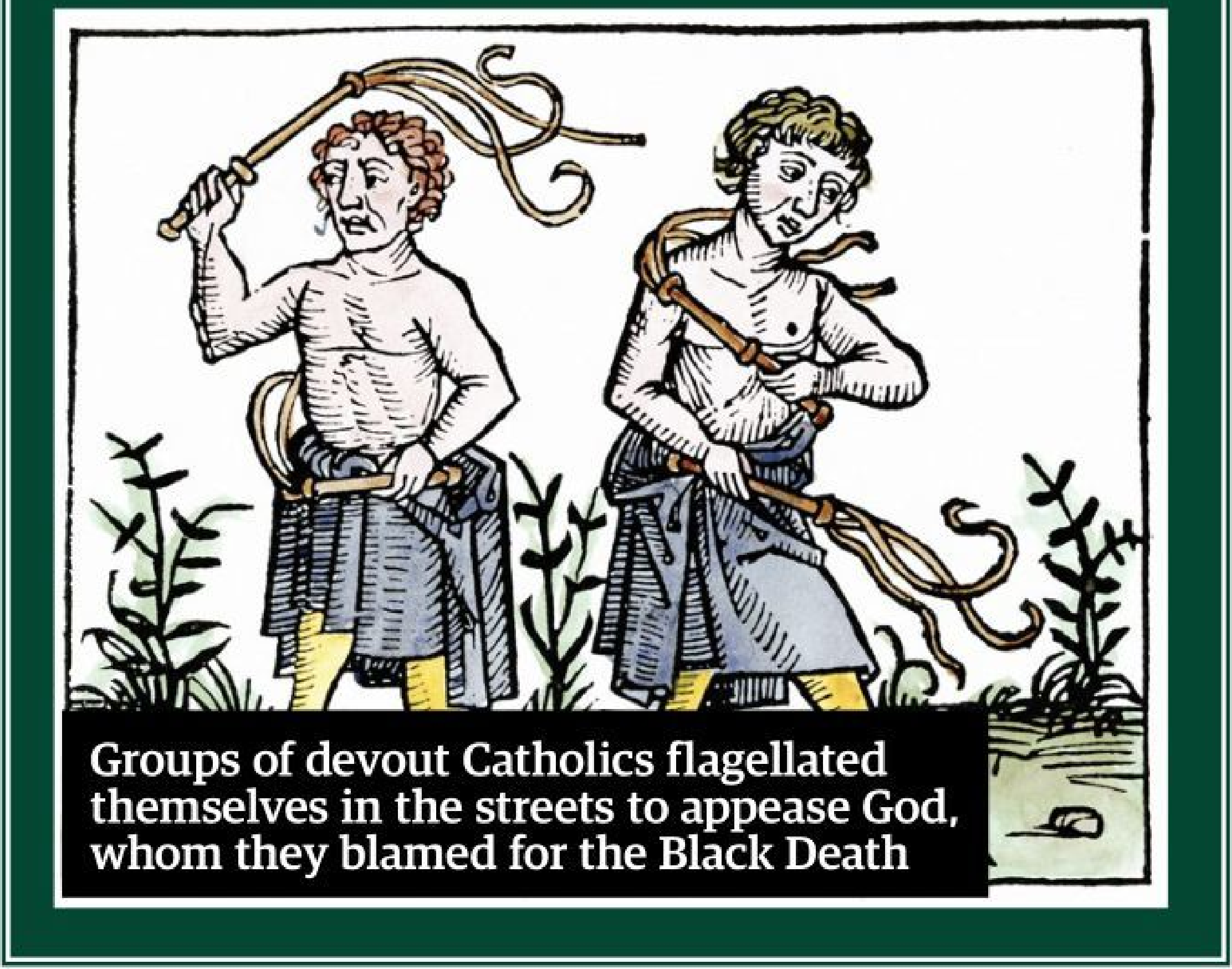
This process was aided by the acquisition of medical knowledge from Islamic nations through immigration, trading and the Crusades. Several Arab nations had already made great advances in their understanding of human anatomy. As more and more of this was translated into Latin, it became readily available to European scholars. They, in turn, combined the new information with a re-evaluation of ancient Greek texts and fresh examinations of dissected bodies. What they discovered gave credence to practical over spiritual diagnoses and treatments and put Medieval medicine on a path that would ultimately lead to the scientific revolution.

THE BLACK DEATH

Otherwise known as plague, the Black Death has generally been attributed to the bacterium Yersinia pestis. It spread from person to person through the air and could also be transmitted by fleas that had bitten infected rats. Rats were common in towns and cities and they also tended to stow away on trade ships, allowing the disease to spread to Europe from Central Asia, where historians believe the epidemic started in the late 1330s.

Although the Black Death is often called the bubonic plague, infection could also be in the form of pneumonic or septicemic plague. Whichever form a sufferer contracted, however, the result was typically an unpleasant death, preceded by the appearance of large boils on the skin, organ failure and bleeding.

Because Medieval doctors were unaware of microorganisms, the spread of the plague was attributed to a variety of non-biological causes including spirits and the wrath of God. Accordingly, attempted cures, such as fumigating with herbs, self-flagellation, and lancing of the boils, or 'buboes', were ineffective. The spread of the disease only began to slow as the human population thinned out and most accounts date the end of the Black Death as around the early 1350s, although there were smaller plague outbreaks after that.



Groups of devout Catholics flagellated themselves in the streets to appease God, whom they blamed for the Black Death

© Alamy, British Library, Getty Images

DAY IN THE LIFE

A MEDIEVAL PLAGUE DOCTOR

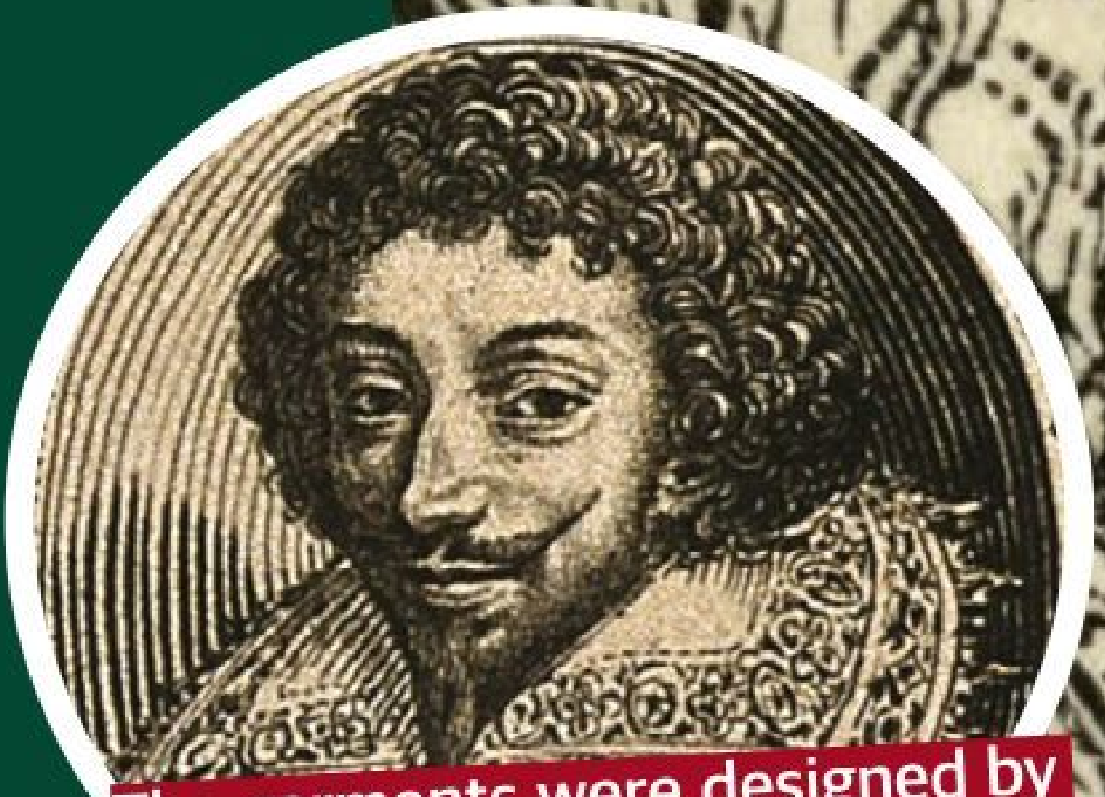
GRIM SPECTRES OF DEATH BATTLING AN IMPOSSIBLE FOE

EUROPE, MIDDLE AGES

Of all the times and places of history to be born in, Europe during the height of the Black Death was probably the worst. The plague ravaged the continent, claiming the lives of 75-200 million people. Cities were wiped out in months and doctors were unequipped to fight its vicious and devastating symptoms. This led most trained doctors to flee, clearing the way for the plague doctors – often second-rate or young physicians trying to make a name for themselves. Although they likely did more harm than good, the image of a doctor in gown and beaked mask has become a dark symbol of a world in turmoil.

GET DRESSED

The most memorable and haunting aspect of the plague doctor was their garb. The outfit was designed to cover the wearer from head to toe, so that no skin was exposed. Plague doctors wore gowns that were covered in wax as well as leather gloves and masks with glass eye openings. Some also wore a beak, which would be filled with aromatic items such as herbs, dried flowers and spices, believed to protect the wearer from the bad smells thought to cause the plague.



The garments were designed by Charles de Lorme, the physician of three French kings – Henri IV, Louis XIII and Louis XIV

EXAMINE PATIENTS

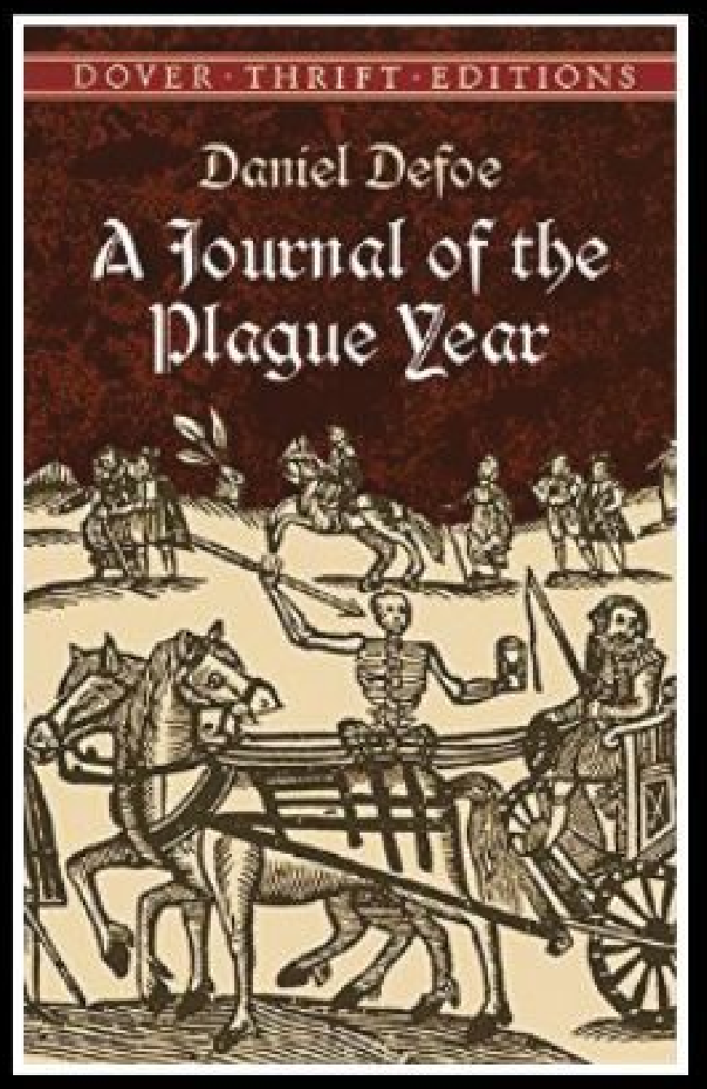
Plague doctors were responsible for examining people suspected of contracting the plague. Symptoms often included swollen lymph nodes called buboes in the groin, neck and armpits that oozed pus, fever and vomiting blood. In order to avoid contact with patients during examination, plague doctors would use a wooden cane, which also came in handy for pushing any of the desperate suffering souls away if they got too close.

ADMINISTER TREATMENT

Not everyone who contracted the plague died, so people were desperate to discover the magical 'cure'. Plague doctors practised a number of peculiar and harmful remedies such as putting leeches on the buboes or giving patients lucky charms. A cure that likely accelerated death was to coat the victim in mercury and bake them in an oven.

How do we know this?

Some of the most startling and memorable descriptions of the Black Death and those who treated it come from those who lived through it. Many of the writers of the period such as Giovanni Boccaccio, Lodewijk Heyligen and Samuel Pepys recorded their experiences in diaries and letters that offer a fascinating and horrific glimpse into history. *The Black Death* by Philip Ziegler offers a full and comprehensive study of the plague, from its origins to the various remedies of the period, supported by contemporary literature. Although it masquerades as fiction, Daniel Defoe's *A Journal Of The Plague Year* builds upon real-life accounts 60 years after the plague ravaged London, to create a truly chilling eyewitness-style account of the terror.



DOVER · THRIFT · EDITIONS

Daniel Defoe

A Journal of the Plague Year

One of the most popular ways of preventing the Black Death was to smoke tobacco; even schoolchildren were encouraged to do it

The beak doctor mask or 'Medico della peste' is now one of the distinctive masks worn during the Carnival of Venice

OFFER ADDITIONAL TREATMENTS

The plague could strike anyone – regardless of how rich or poor they were, and some of the more corrupt plague doctors were eager to exploit this. Some families were willing to try absolutely anything if they thought it would cure their loved one, and dishonest docs would sell their 'cures' at high prices. One example of such a cure was 'plague water', which apparently contained frogs' legs and powdered unicorn horn.

DO PAPERWORK

Just like doctors today, the vast majority of the plague doctors' time was taken up by filling out paperwork. As they were officially hired as public servants by the town, the doctors' main task was to record the number of deaths caused by the plague in public records. They were also called upon to testify and witness the signing of wills, not only for those who were dying but for those who had already passed as well.

PERFORM AN AUTOPSY

The people of Medieval Europe were desperate to rid themselves of the devastating plague and so were willing to waive certain rules in order to do so. Although autopsies were generally forbidden at the time, plague doctors were allowed to perform them on plague victims. It was hoped that the procedures would help the doctors to determine the exact cause of death and hopefully lead to the discovery of a cure.

RECEIVE SALARY

The plague doctors were officially hired by the city officials, and it was from the city that they received their salaries. Because of the lack of qualified medical doctors due to the outbreak, plague doctors often received an inflated salary. For example, when Matteo fu Angelo was hired by the city of Orvieto, they paid him four times the normal rate of a doctor. Despite this, some plague doctors would still sneakily charge their patients extra for special treatments.

CATCH THE PLAGUE

Due to their close contact with plague victims, the 'beak doctors' were often placed under quarantine, unable to interact with the general public for a set period of time. For example, some doctors were isolated for up to 40 days at a time. This was for good reason – unsurprisingly, the vast majority of plague doctors caught the plague from their patients and soon perished themselves. During the outbreak in Venice, 18 plague doctors were hired for the city by officials. Less than a year later, just one remained.

In 1665 the plague claimed the lives of up to 100,000 people in London alone

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HOW TO

TREAT THE BLACK DEATH

FIGHT THE GREAT PESTILENCE JUST AS MEDIEVAL PHYSICIANS DID

ENGLAND, 1300S

When the Black Death came to England in 1348, it left a trail of devastation in its wake. More than 1 million people fell victim to the disease that had already swept through Europe, wiping out millions as it continued its merciless progress through the land.

The cause of the Great Pestilence was a mystery and, as doctors struggled to find a cure, some outlandish methods of healing the infection emerged. In this simple guide, you'll learn how to treat a case of the Black Death just as doctors in the Middle Ages did. Whether you'll live to tell the tale is another story.

The doctor is in

Plague doctors might look fearsome but they were actually helpless against the scourge of the Great Pestilence.

Meet the patient

Stricken with pain, the patient suffering from the Black Death faces a bleak and uncertain future.

Cut them open

Using a sharp blade, open the vein of the inner elbow on the side where the patient is experiencing the most pain.

Apply the leeches

Apply leeches to the wound. If the infection is already severe, open more veins and apply more leeches.

Remove the leeches

Once the leeches have grown fat and fallen off, return them to their jar and dress the wound.

WHAT YOU'LL NEED...

01 TIME TO BLEED

As soon as the patient shows even the slightest symptoms of the plague, there's no time to lose. Ask him which side of his body is the most painful and have the surgeon open a vein in the arm on that side or, even better, apply leeches liberally to the painful areas. Bleed him until his soreness dissipates.

02 TAKE YOUR MEDICINE

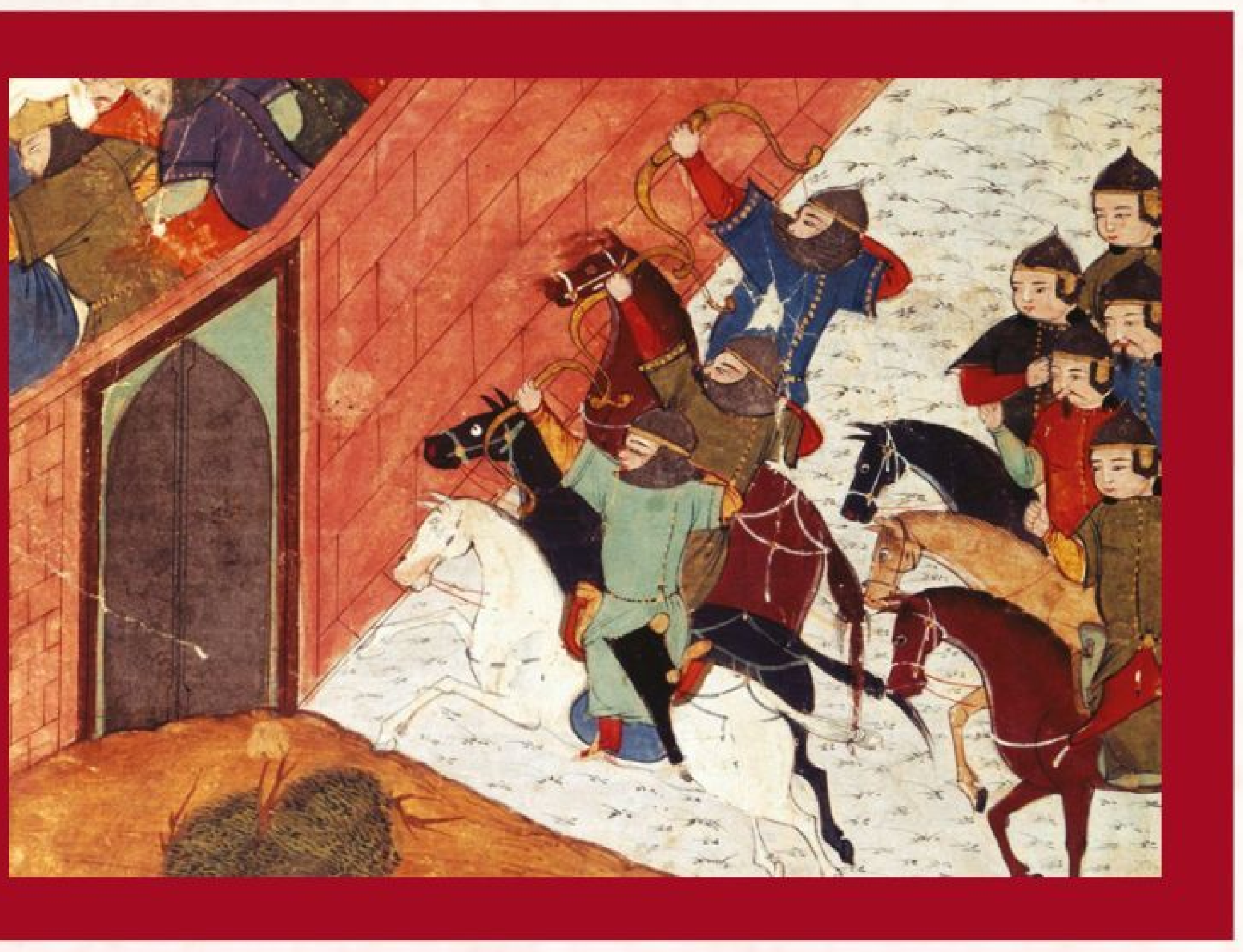
There are all sorts of natural remedies, known as plague waters, available for the Black Death, and your local doctor will know which one is right for your patient. To make your own, mix angelica, juniper, figs, saffron and vinegar. Add a little nutmeg to taste and serve hot – this will encourage the patient to sweat out the pestilence.

How not to... dispose of a body

As the Black Death ravaged the lands, plague pits became a familiar sight, along with vast bonfires on which the bodies of the dead were burned. In the Crimean city of Kaffa in 1347, however, the Mongolian Tatars decided on a very novel way of disposing of their plague dead.

Tatar warriors had besieged the Italian inhabitants of Kaffa without success for months, hoping to drive from the city. Now, with their ranks depleted by plague, the dispirited Tatars began catapulting plague-ridden corpses over the city walls. The Italian populace took fright and many fled Kaffa for their homeland, bringing the Black Death with them to mainland Europe.

This incident is one of the earliest known examples of biological warfare. Though the impact on the mainland was devastating, the Tatars did not conquer Tatar and the city remained under Italian control.



03

BURST BUBOES

As the plague progresses, the telltale buboes will start to appear, most commonly in the groin and armpit. These must be purged without delay as they contain the disease. Apply a hot poultice of lily root, ale grounds and mallow to bring out the boil then pierce the bottom of the buboes to drain out the poison.

04

SWEAT IT OUT

If your patient is mobile, encourage him to sit between two fires; if he is in bed, surround him with bottles filled with hot water. The patient should sweat for a minimum of three hours, preferably even more, as this will encourage the infection out of the body. Dry him off, dress him warmly and put him back to bed.

05

FUMIGATE THE 'BAD AIR'

While the patient rests, it's time to fumigate the miasma. Cleansing the air will help ward off the plague and treat those already suffering. Hang posies of rosemary, sage and lavender in the house, particularly in the sickroom. You can increase the efficacy by keeping a heated bowl of vinegar near the patient and allowing the steam to disinfect the air.

06

REPEAT AD NAUSEAM

Repeat the treatments, occasionally feeding the patient small amounts of simple food such as chicken or veal washed down with mild ales. The patient will soon be on the road to recovery or, sadly, taking a turn for the worst. If your efforts aren't successful, don't feel too disappointed – millions have already fallen victim to the Black Death.

IF THAT DOESN'T WORK, TRY THESE CURES...

FLAGELLATE

Join a flagellation procession and whip yourself for your sins, thus earning God's forgiveness and ridding yourself of plague.

CHICKENS

Pluck a live chicken and hold it against your buboes. This will draw the poison out of you and into the unsuspecting bird.

PIGEONS

If chickens don't work, slice up a dead pigeon and rub its entrails all over your body.

FAECES

Open the buboes and smear them with a paste made from human faeces, tree resin and plant roots. Be sure to bind the wounds up tight!

EMERALDS

Richer patients can crush emeralds into powder, mix them with broth and down them in one gulp.

© Ed Crooks, Getty Images

TALES OF TUDOR MEDICINE

In Tudor England, a toothache, a gangrenous finger and an excess of blood would be dealt with by the same man who cut your hair – the barber-surgeon

The average life expectancy in Tudor England was about 35 years, and of all those born, somewhere between a third and half died before they reached the age of 16. Life could be a short, brutish struggle, especially for those born without wealth or privilege, but if they managed to survive to their late teens, then the chances were good that they would make it to their 50th or even 60th birthday. And just like nowadays, some people in Tudor England even lived to their 70s or 80s. For the most part, however, people were losing a war against sickness and disease that they barely understood, let alone knew how to fight effectively.

It wasn't until after James Stuart took the throne, closing the Tudor period, that William Harvey's theory of blood circulating around the body in a closed system gained a foothold in medical science; or that Athanasius Kircher started researching disease using a microscope; or that Robert Hooke discovered cells, leading Antonie van Leeuwenhoek to discover bacteria. Only a generation or two before in the Tudor period, the revolutions in medical science were just starting to gain pace, and most people believed that your astrological sign, your adherence to the advice of a poem and the composition of your urine were the real diagnostic tools. They were damnably dirty days, too.

> Tudor medicine mostly consisted of herbal remedies, known as 'simples', and most women would have known the recipes

Timber and whitewashed wattle-and-daub walls pressed into each other over the roads of towns and cities, forming arched roofs over the stinking streets and enclosing the stench. Citizens slopped their night-buckets out into the open sewers beneath, which drained along channels thick with lice, fleas and black rats, dragging discarded and rotting rubbish with them. The physician John Snow wouldn't be born until 1813, and until his ground-breaking research on the Broad Street cholera epidemic in London and its spread through the water pumps was published, no one would know that all this infected liquid was permeating and poisoning the wells, creating hotspots of infection that seemed like cursed neighbourhoods to the stricken populace. Tudor England was woefully ignorant of effective sanitation – many believed that bathing was dangerous, opening the pores to malevolent bad air that would make them sick – and people instead followed the guidance of, chiefly, learned doctors, local wise women and a very multi-skilled kind of surgeon.

Favoured by Henry VIII and those who could afford them were the physicians, who were gentlemen, academics and costly. Henry himself was very interested in medicine, founding the

Painted by Franz Anton Maulbertsch in the 18th century, *The Quack Doctor* shows a barber-surgeon pulling teeth at a temporary stall in town

Barber-surgeons performed bloodletting, removed teeth and trimmed hair, among other things

Royal College of Physicians in 1518, merging the Company of Barbers and Fellowship of Surgeons into a single company in 1540 and passing several other acts of parliament throughout his reign that established licensing regulations for medical practitioners. These would stand for the next three centuries. He even had an early insight into the spread of disease, long before Snow, that led him to implement quarantines during the later plague years and introduce basic disinfection, as well as attempt to improve the sewers and water supplies. But he always trusted his physicians and their intuitive, though often incorrect, ideas – they were the experts, after all.

Astrology played a big part in Tudor medicine, and many physicians would prescribe treatment based on the patient's star sign

Since the Black Death had arrived in Europe during the 14th century, pandemics had re-occurred over the years and created a new class of physicians – plague doctors. Thickly robed from head to toe, the plague doctor would enter a patient's chamber with a pungent air of herbs and oils, cloying bundles of clove, camphor, laudanum and bergamot hanging from pouches at their waist to protect against miasma, and amulets worn around the neck and waist to ward off sickness. They were always gloved and carried a cane so they wouldn't have to touch their patients during examinations, and wore a striking, beaked mask with glass lenses sewn in to see through; the beak was an air filter, filled with another heady mix of aromatics. Though they didn't understand it, some of these precautions were successful and helped the plague doctors avoid death.

Most physicians were less adventurously attired, however, and instead emerged from seven years of study – often overseas at the esteemed medical college Salerno – in stiff suits, bearing astrological charts to determine which kinds of medicines and incisions should be avoided based upon astrological signs. They would mentally consult and then recite lines of the *Regimen Sanitatis Salernitanum (The Salernitan Code Of Health)*, an archaic anthology of medical advice in poetic form that was an authoritative textbook at the time, translated into dozens of languages and hugely popular because of its memorable rhymes dispensing such sage advice as this:

Of Pork
Inferior far to lamb is flesh of swine,
Unqualified by gen'rous draughts of wine;
But add the wine, and lo! you'll quickly find
In them both food and medicine combined.

And also this more pertinent verse:

Of the Four Humours in the Human Body
Four humours form the body in this style,
Atrabilis, Blood, Phlegm and yellow Bile.
With earth atrabilis may well compare,
Consuming fire with bile, and blood with air.
Blood is moist, warm, and vital as the air;
While phlegm is cold, through water's copius share;
Bile burns like fire, where'er it flows along;
Gall, dry and cool, to earth bears likeness strong.

HENRY'S FALL

Henry VIII displayed two wildly different personalities during his tenure as king of England – in his early days, he was a sporty, courtly and charismatic chap described as having a beautiful face and shapely calves, while in his latter years he became a man of fearsome temper and girth. He was seen as cruel and fearfully whispered of in the halls of Greenwich Palace. He was also said to stink in his later years – apparently he could be smelt from three rooms away.

Historians believe there is a connection between Henry's health and his shift in personality. Henry began life in excellent health and was renowned for his athletic pursuits, among which were wrestling, tennis and jousting. However, he may have contracted smallpox aged 23 and definitely picked up malaria at some point in his 20s, which was to exacerbate his struggle with the leg ulcers he later developed. The first recorded mention of his ulcers comes in 1527, when he was 36 – shortly after recovering from a tennis injury that left his foot so swollen he took to wearing a single, loose velvet slipper. Henry was afflicted with a "sorre legge" for the rest of his life.

When he was 44, he suffered a terrible jousting accident that threw him to the ground and saw his armoured horse land on top of him. He was "without speech" (unconscious) for two hours, and one of the ulcers tore open. This ulcer left Henry in chronic pain for the rest of his life, and physicians insisted on keeping the wound open in order to drain it of excessive humours – actually stitching the skin back and inserting gold pellets into the wound to keep it open while it drained. Unable to exercise and racked with pain, Henry's waist ballooned further, and he developed a filthy temper. Historians note that his cycles of marriage and divorce sped up after the accident, as did the number of executions he ordered, and by the time he died 12 years later, his legs were so infected he had to be carried around on a chair.

This, essentially, was the core of medical thinking in Tudor England, and it all went back to an Ancient Greek scholar called Galen. He was a consolidator of medical knowledge in his time, gathering all that he learned and dictating his books to teams of scribes. Galen was so prolific that, despite much of his work being destroyed, his writings represent almost half of all the Ancient-Greek texts we have today. His theories were lost for a time after the collapse of the Western Roman Empire as Galen's work, which had not been translated into Latin during the days of the empire, fell into obscurity in the west. Some of his works had been exported to and survived in the east, though, and were later rediscovered in Europe, at which point ideas such as Galen's belief in the four humours as a governing force of health became accepted as scientific fact.

> One 'cure' for smallpox was to hang red curtains in the patient's room. It was thought that the red light was medicinal

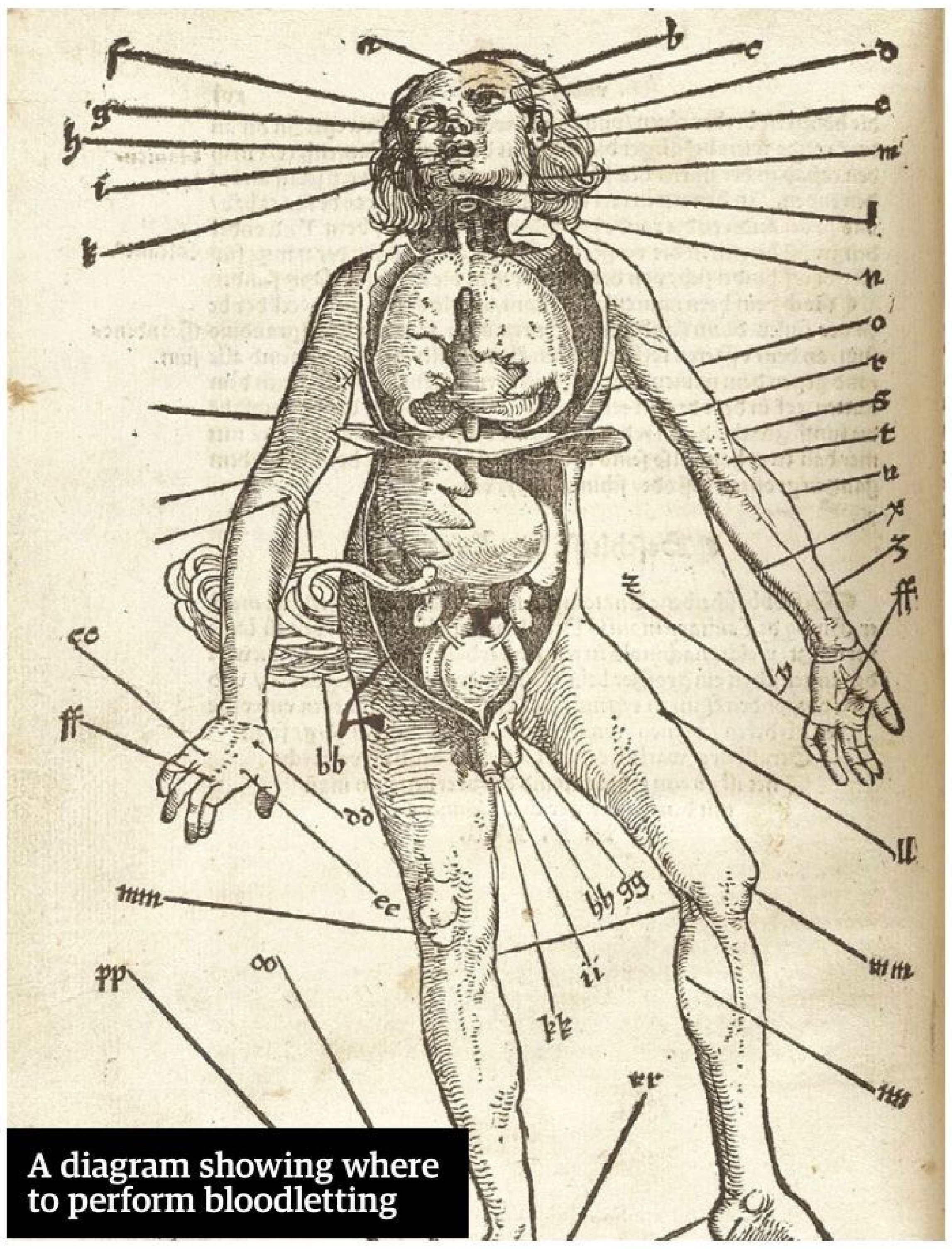
Blood, phlegm, black bile and yellow bile – the humours – were tied to the elements, the seasons and to your personality and physical characteristics. Fiery sanguinous folk, for example, were thought to be red-cheeked and rude of health, maybe a little mischievous but otherwise quite sweet. Melancholics, ruled by earth and black bile (atrabilis), were thin, sickly and introspective. Phlegmatics were foolish and Cholerics were ambitious. Most important was the balance of the four humours within a person – evacuation of any excess of a humour was the foundation of many courses of treatment, whether that meant providing laxatives or leeches. So using their knowledge of a patient's birth sign, the phase of the moon and the positions of the stars, combined with a thankfully more helpful physical examination to observe symptoms, and then the advice of the *Regimen*, physicians would diagnose patients and recommend various tinctures, elixirs and practices to alleviate their suffering, as well as perform more hands-on operations where necessary.

Plague doctors, for example, would lance the buboes of the infected, while physicians performed phlebotomies to drain excess blood and used trepans to tap holes into heads that were suffering migraines. For the most part, though, seeing a physician in Tudor England was a little like seeing your doctor today – they'd prescribe a course of medicine and send the patient for a visit to the local pharmacy.

In this case, the pharmacy was the apothecary. Serving the rich and poor alike, it was an emporium of home-made remedies and locally harvested medicinals, not to mention more exotic ingredients. The apothecaries were governed by the Grocer's Guild, so there were always also boxes of confectionaries and perfumes among the herbs and tonics, and they usually kept their own gardens to supplement their stock. It was in high demand, too – the Tudors took dill for digestion, dandelions for boils, liquorice for lung problems, wormwood for stomach pains, onions and garlic to create poultices for wounds; they treated headaches with sage, lavender, rose and bay; and they cured headlice with tobacco juice. There were scores of medicinal recipes and, whether a physician or a wise woman sent them, they would pick up their prescription at the apothecary.

If a patient found themselves in need of a tooth pulling, however, or perhaps a more serious operation, then they would instead continue on down to the street until they saw the barber's

A man being treated with bloodletting


A diagram showing where to perform bloodletting

Leeches were another common form of treatment, used to remove 'bad blood'

Diary of a barber-surgeon

An hour after sunrise

Just opening up and this poor fellow is hammering on the door, comes in with terrible toothache. Looked like the tooth worms were deep into their cups and the clove wasn't driving them out, so it had to be pulled. Nearly spilled the whisky when he saw the pliers.

Mid-morning

Urine diagnosis for a gentleman feeling out of sorts; too cold and foamy, an excess of phlegm causing a common cold. Recommended some of those excellent cinnamon, ginger and mustard biscuits from the lady down the way and a cooked apple to help fight off infection.

Noon

Went down to the marshes to buy leeches from the thatchers collecting reeds. Also purchased more whisky, bandages, fox grease, dried toad and marjoram from the apothecary. Butcher is still charging exorbitantly for his donkey and pig skins and I cannot seem to find a decent smith for my next set of scalpels.

Early afternoon

Amputation went well – cut and tied 50 or so veins and arteries in a little over nine minutes, I believe a personal best. Patient roared something awful, though, and the cauterisation was messy. Good thing I got those leeches – I pray he doesn't end up needing the maggots.

Twilight

The early-rising merchants are dropping in on their way home for haircuts. I must remember to empty out all of the bleeding bowls later. It was a little unprofessional having to empty one for use with one customer who had filled his bowl while another waited with half a beard trimmed.

Late evening

Closed the shop for the day, swept up the hair and sopped up the blood. Most of the hair can be salvaged for the premium perukes, but the more soiled batches will have to be used in lower value wigs for the market. I must remember to empty all of those bleeding bowls tomorrow.

pole above their head, the spiralling red and white stripes signifying the bloodied bandages of the barber-surgeon. These were the qualified knife wielders who handled the business end of medical care, performing an amputation in the morning, wiping off their tools and then trimming a moustache in the afternoon. Often, they'd begin with a uroscopy, smelling and tasting a urine sample to determine its humouric composition and then comparing its colour to charts. A hugely common treatment in those days was bloodletting, going back to Galen's theory. From bad tempers to fevers, an excess of blood in the body was to blame for many problems, and both barber-surgeons and physicians had a wide array of instruments to help let some out. Using scarifactors, they'd make scores of tiny incisions along the backs of patient's legs and collect the excess in a special bleeding bowl, sometimes marked with a scale in fluid ounces, or instead they'd use lancets, leeches or fleams to balance the humours.

Throughout the Tudor period, however, new ideas began to emerge that would change everyone's perception of health, the body and medicine forever. In 1546, for example, Girolamo Fracastoro published a book called *On Contagion* that argued sicknesses and infections were actually spread by 'disease seeds'.

There was a man named Theophrastus von Hohenheim who styled himself as Paracelsus, in opposition to the Ancient Roman writer Celsus and his book *De Medicina*, which had been published in 1478 and quickly become a standard medical text despite being as old as Christ. Paracelsus – 'beyond Celsus' – was alchemically trained, and he challenged this outdated way of thinking, introducing the use of chemicals and metals to medicine, such as using mercury to treat syphilis. He's widely regarded as the founder of toxicology and rejected teachings that weren't based on observations.

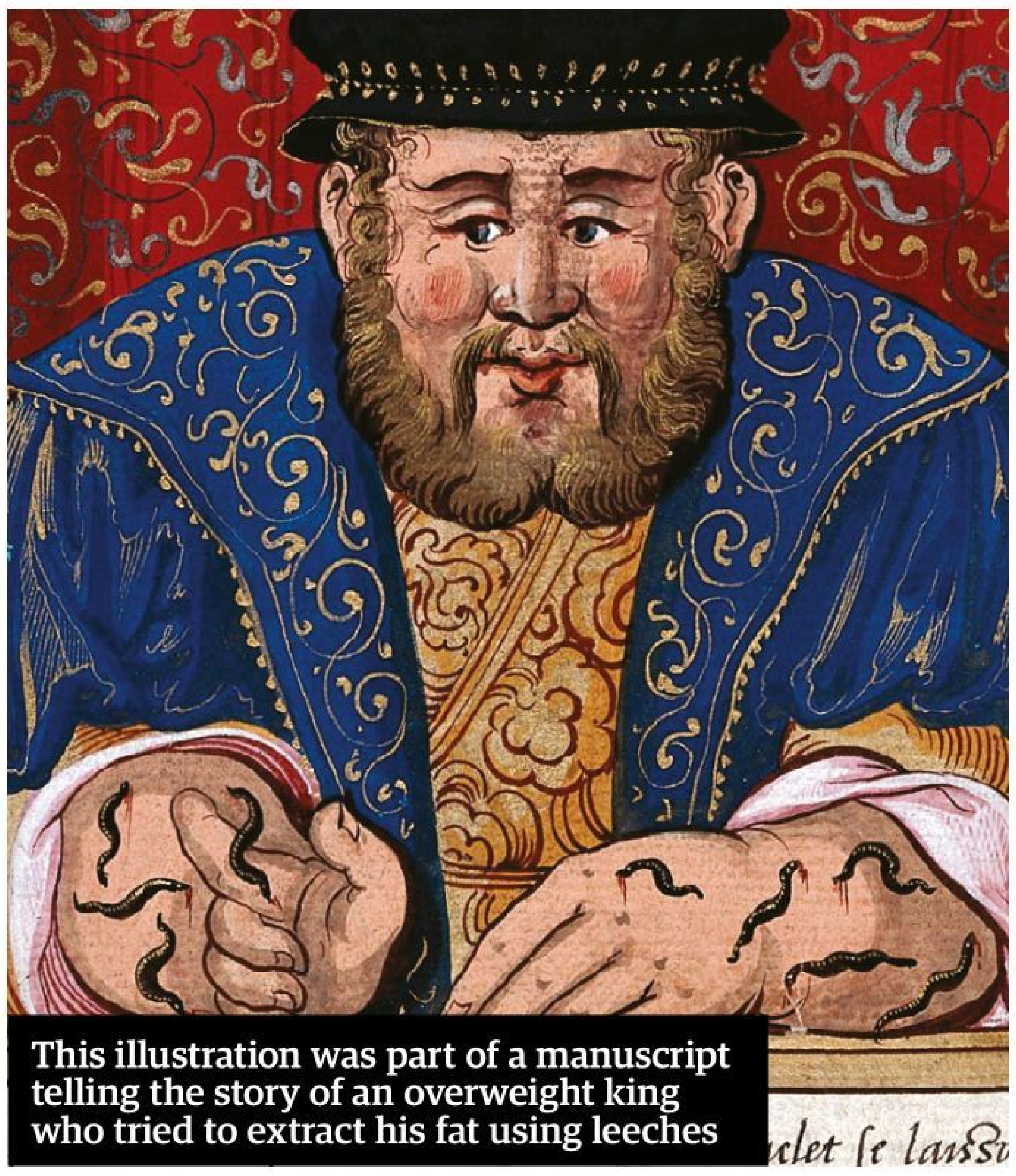
Another man to reject the teachings of thousand-year-old orators was Andreas Vesalius, one of the greatest surgeons of his time (though a physician, rather than a barber). As well as forming the Company of Barbers and Surgeons of London, Henry VIII also legalised human dissection in 1540. This meant that doctors such as Vesalius could finally perform human autopsies, often in large theatres where students could observe, and gain a better understanding of how the body worked.

Following the instructions of Galen, which had been based on the bodies of pigs due to the similar illegality of human dissection in his time, doctors found that Galen was wrong. So Vesalius made his own observations and published a ground-breaking book called *De Humani Corpus Fabrica (On The Fabric Of The Human Body)* that contained incredibly accurate diagrams of the human body – something people had never seen before, made possible by both the legalisation of dissection and the detail afforded by mass-printable woodcut illustrations. To recreate the experience of an autopsy, Vesalius included flaps that could be lifted up to reveal layers of muscle and bone, veins and arteries, the positions of organs and the insides of the brain. The insight that *The Fabric* gave to Tudor doctors was invaluable, helping to clear the air of Galen's obscuring theories on humours and miasmas.

Tudor England was an age of great discovery for medicine, the beginning of a revolutionary period of change that would see the arrival of sanitation, chemical drugs and microbiology. While for those receiving the sharp attention of a barber-surgeon or looking along the beak of a plague doctor it may have seemed a brutal time to be alive, it was a time of changing attitudes that would soon lead to the beginnings of modern medical practices, and the levels of both comfort and survivability that we enjoy today when in the care of a doctor.

In 1543, Andreas Vesalius donated a preserved skeleton to the University of Basel, where it is still on display today

> "Physicians performed phlebotomies to drain excess blood and used trepans to tap holes into heads that were suffering migraines"


This illustration was part of a manuscript telling the story of an overweight king who tried to extract his fat using leeches

Defining moment

Henry VIII's jousting accident

24 January 1536

During a jousting tournament at Greenwich Palace, King Henry VIII is thrown off his horse, which lands on him, and falls unconscious for two hours. The accident nearly kills him and marks a turning point in his life, leading historians to wonder if he incurred a brain injury. It was also said to have shocked Anne Boleyn so greatly that it caused the miscarriage of their son. When Henry found out, he turned against Anne, believing she would never provide him with a male heir, and within half a year he had her executed and married his next wife, Jane Seymour.

Timeline

157 CE

Galen's work begins
Ancient Greek physician Galen is making his name as a doctor, treating injured gladiators and writing his medical texts. His work will inform medical education throughout the Western Roman Empire.
157 CE

Manuscripts lost
Romulus Augustus, last emperor of the Western Roman Empire, is deposed and the empire falls. Galen's work, which has not been translated into Latin, falls into obscurity for hundreds of years.
476 CE

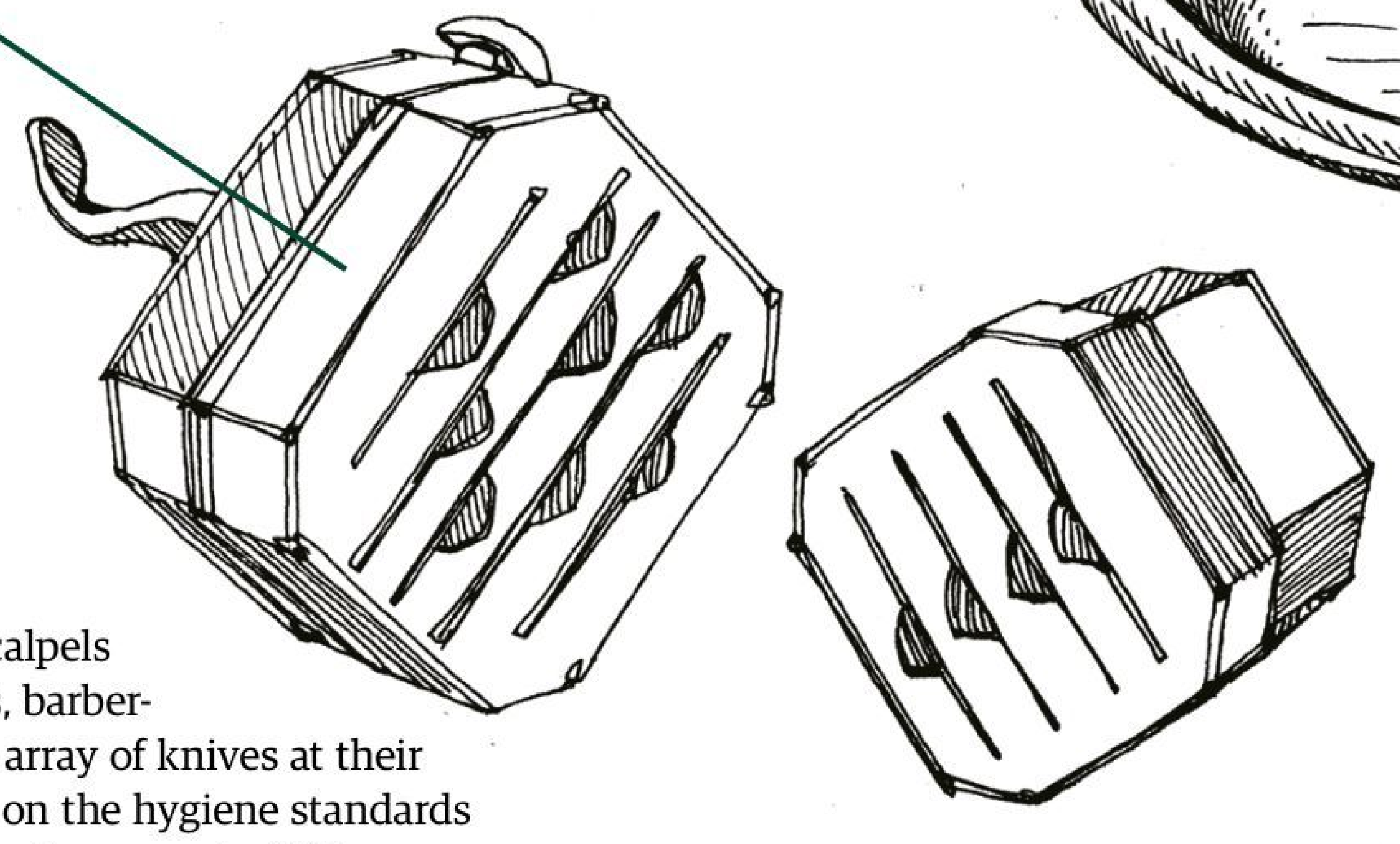
Textbook translation
Guy de Chauliac completes his *Chirurgia Magna (Great Surgery)*, drawing heavily on the recently rediscovered works of Galen, translated by Niccolò Deoprepio of Reggio. It becomes a standard medical textbook.
1363

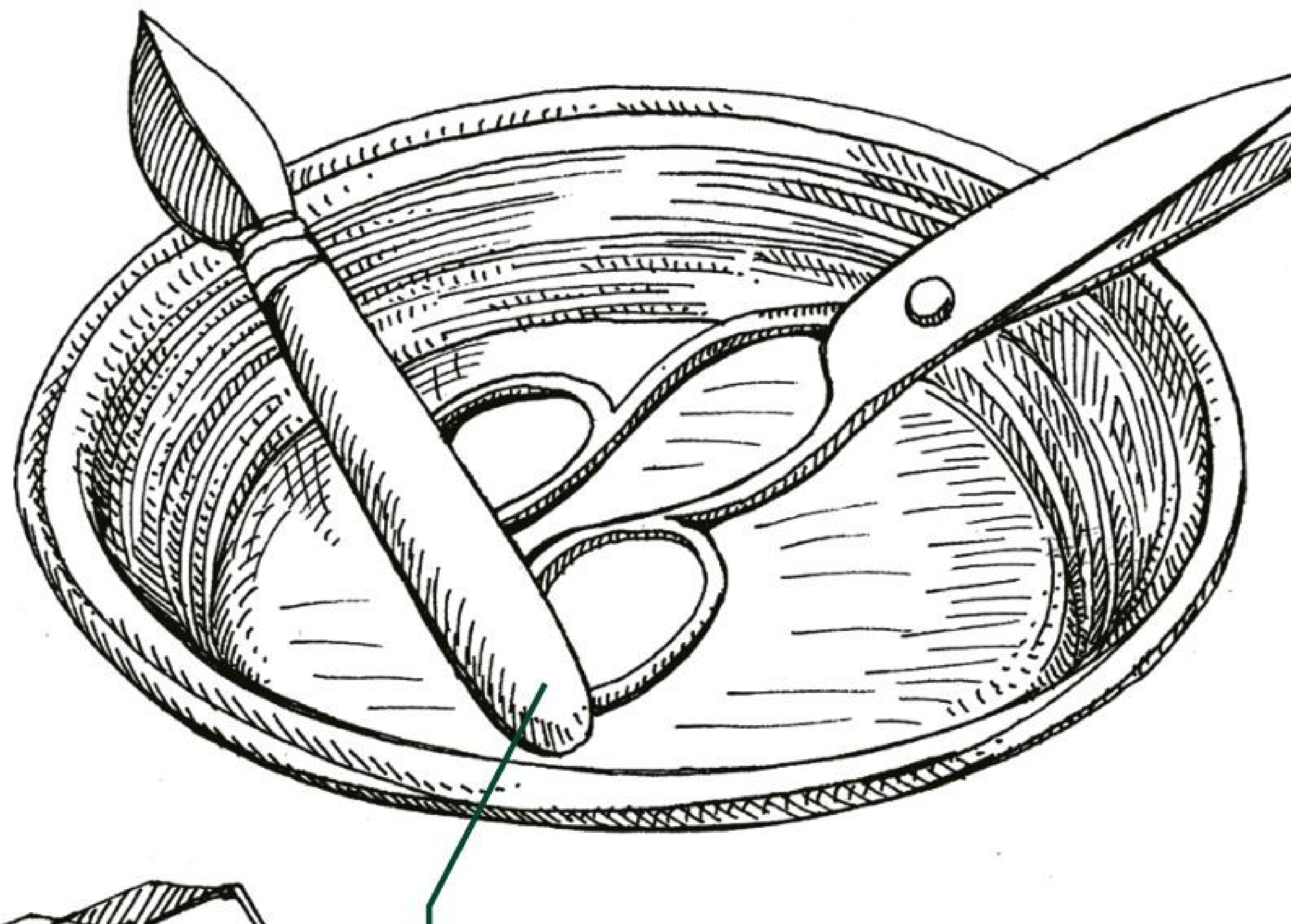
Royal charter
Edward IV grants a royal charter to the Barber's Guild, who become the Company of Barbers, granting them regulatory power over the practice of surgery in London.
1462

Poetry in medicine
The *Regimen Sanitatis Salernitanum*, believed to have first been written in the 12th or 13th century, is published and quickly gains scholarly approval, and widespread recitations.
1480

Midwifery manual
Der Rosengarten (*The Rose Garden*, published in England as *The Birth Of Mankind*), one of the most detailed books about childbirth so far, is written by Eucharius Rosslin, becoming a standard manual for midwives.
1513

Tools of the trade





Scarifactor

A precise, painful-looking piece of work, the scarifactor was a multiplication of the lancet blade. Tiny slices of metal sit in rows and enable the blood-letter to speed up their work, quickly carving out exact measures of blood in regiments of light surface wounds across the patient's body.

Lancet

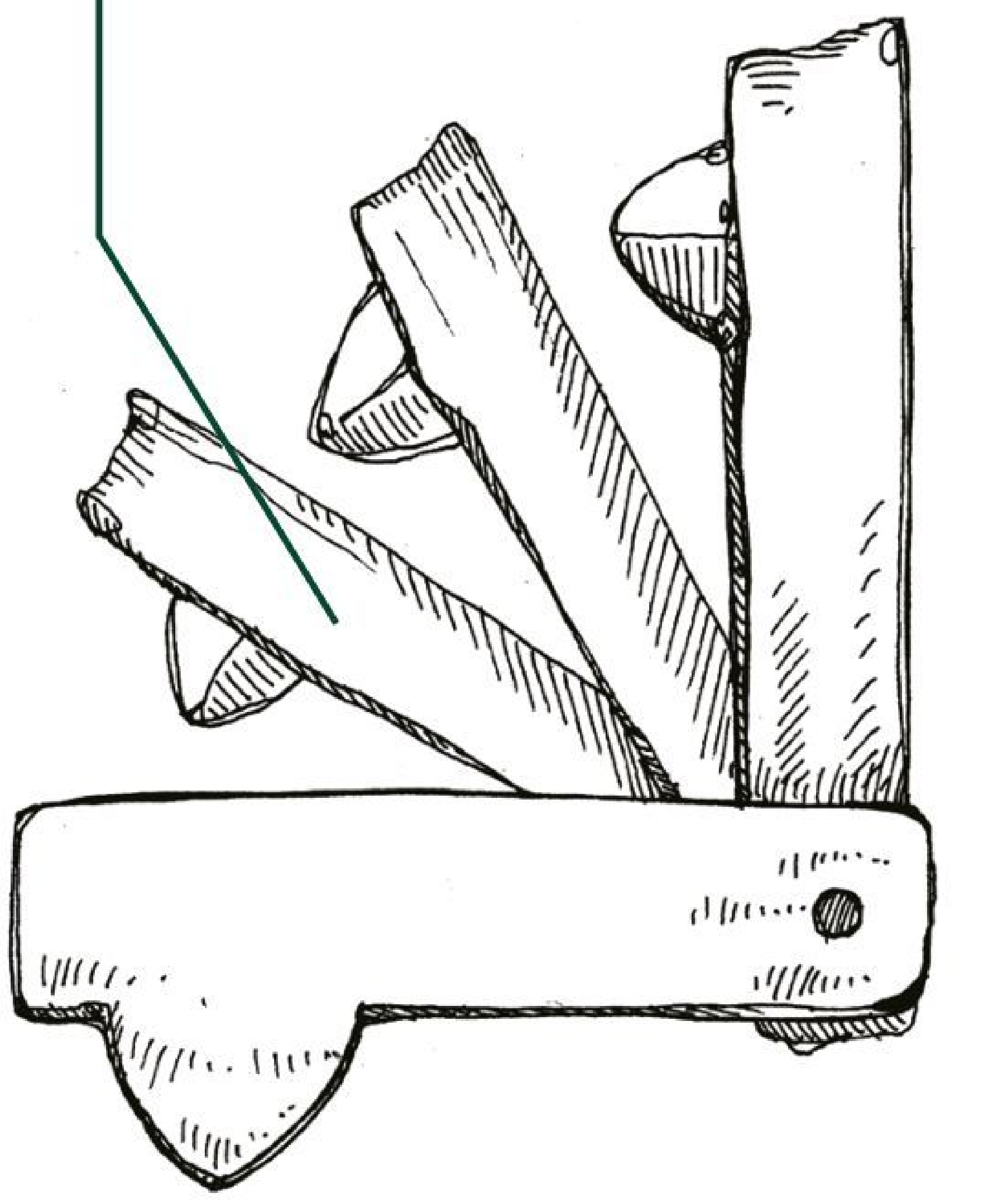
A core tool of the phlebotomist, lancets were small triangular blades with a groove to channel spilled blood, which would be inserted into key points around the patient's body depending on their particular imbalance of humours and astrological readings, then drain away a healthy amount of blood.

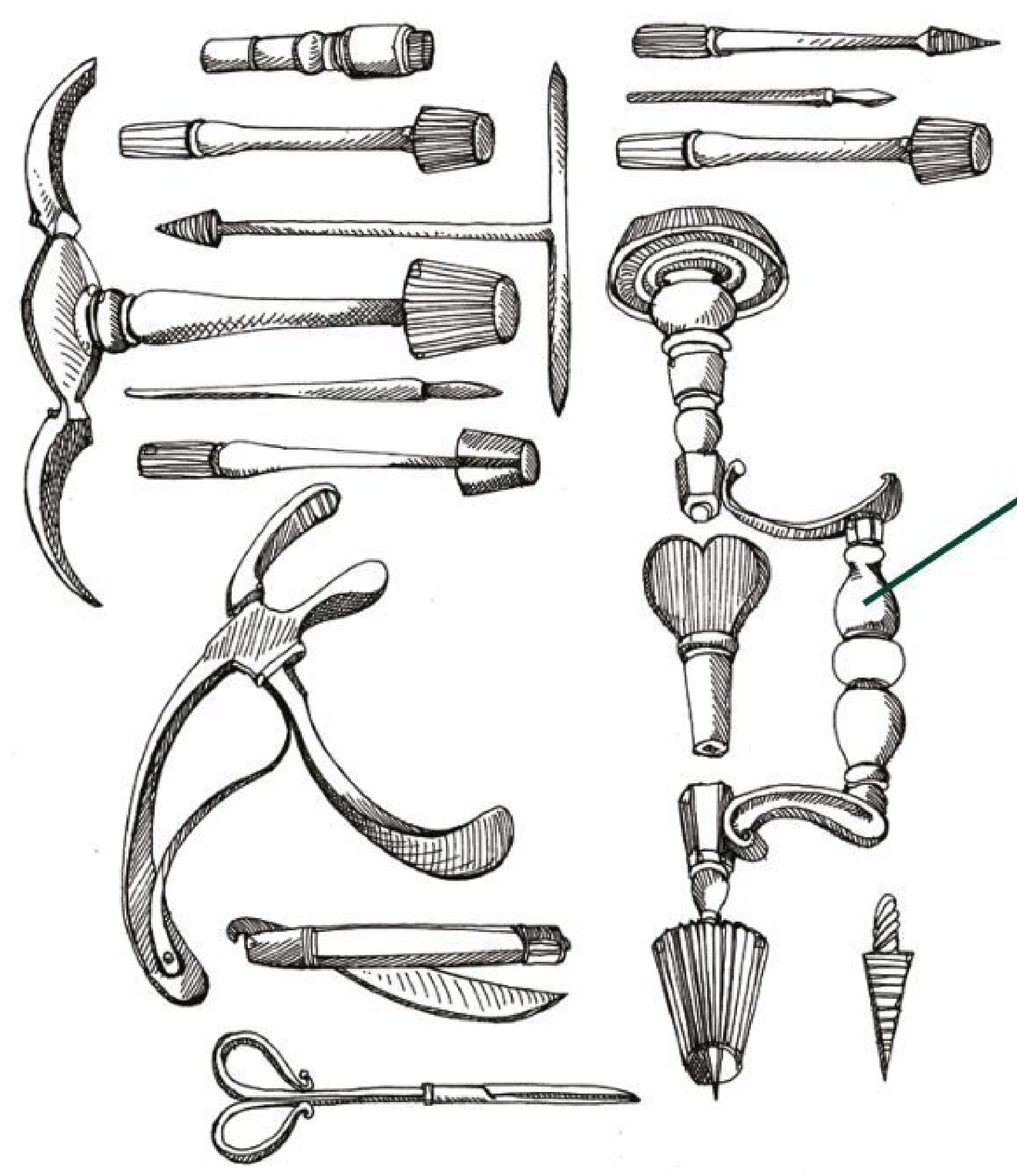
Fleam

Similar to the lancet, the fleam had a small triangular blade designed to puncture veins, but this instrument was made to be as fast, accurate and painless as possible. It came with a special fleam stick, and if you tapped the tool with the stick, then the attached blade would instantly pierce the skin.

Knife

Ranging from tiny scalpels to great meat carvers, barber-surgeons had a wide array of knives at their disposal. Depending on the hygiene standards of the surgeon in question, you could live or die depending on the cleanliness of the blade – more often than not, they'd simply be rinsed in cold water between uses.



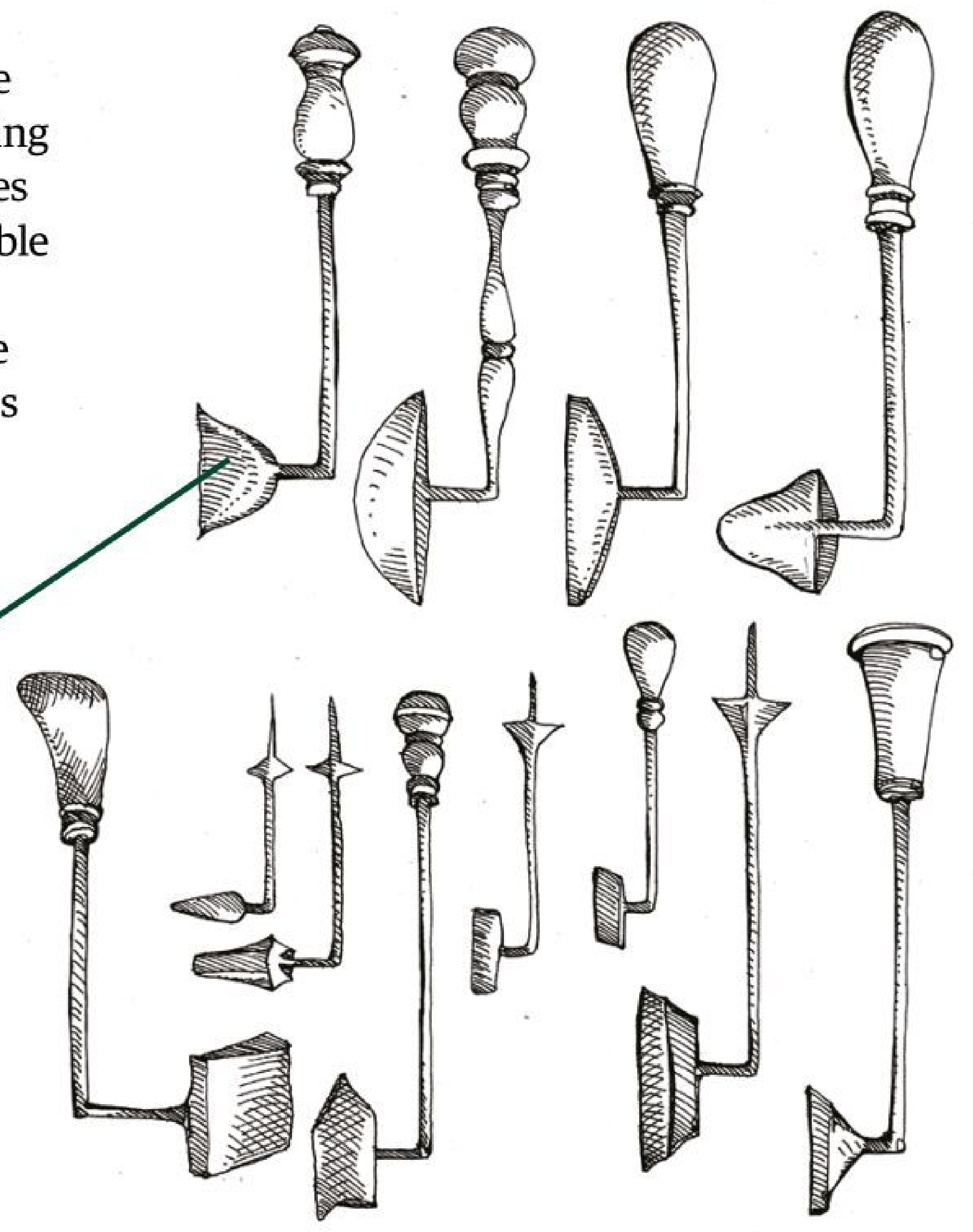


Trepan

Used to bore holes into the skull, the trepan was essentially a bone-grinding corkscrew. At the time, most illnesses of the head were thought to be curable by exposing the insides of it to a little more fresh air, whether they be migraines, epileptic fits or symptoms of ADHD.

Cautery iron

When amputations needed to be made, barber-surgeons used a great circular knife that could whip all the meat off a bone in one stroke, followed by a heavy saw in as few seconds as possible. They would then seal the wound by stretching pig skin across it and using a hot cautery iron to burn everything shut. No anaesthetics beyond alcohol, mind.



Defining moment

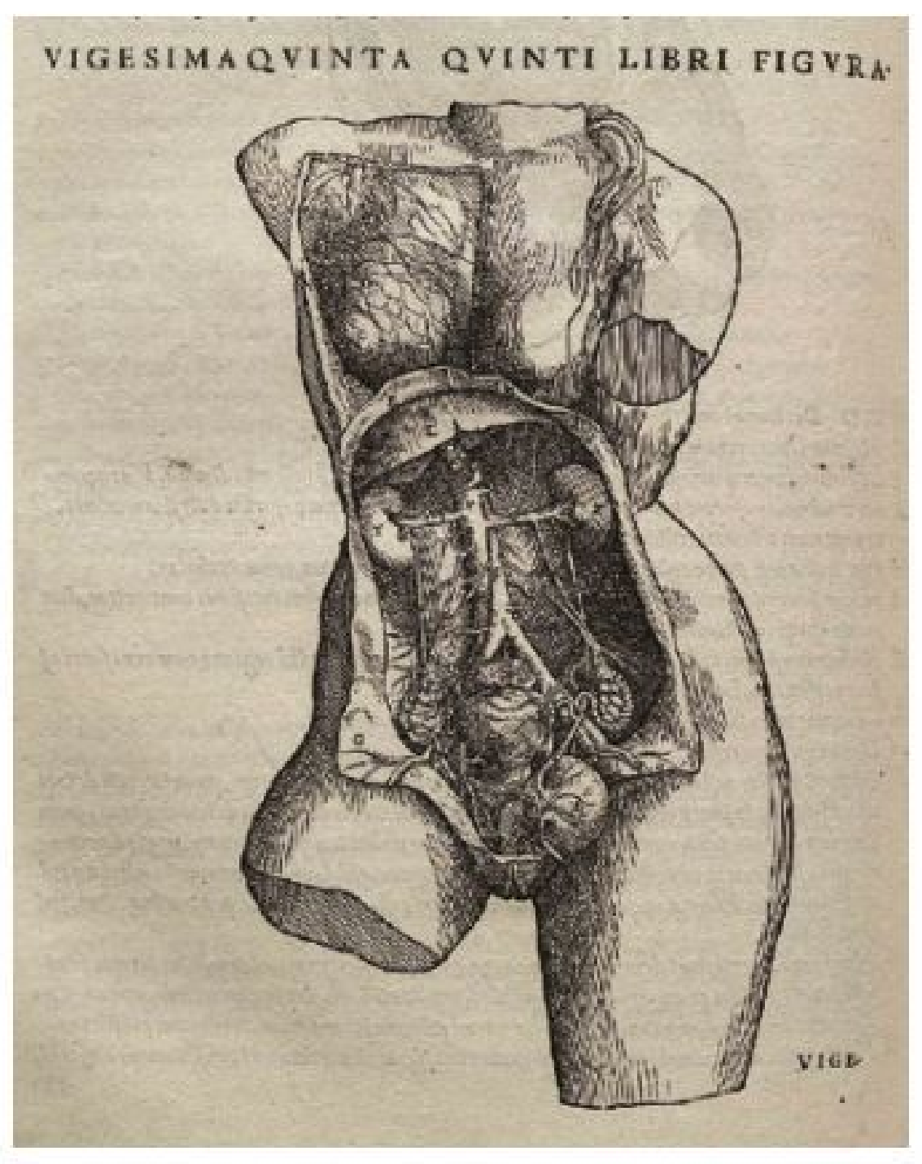
The Company of Barbers and Surgeons 1540

The roles of barbers and surgeons are further defined as the Barber's Guild and the Fellowship of Surgeons are merged into a single organisation. Barbers can no longer practice surgery and surgeons can no longer cut hair or shave. Both can continue their dental work.

Defining moment

Galen's era ends 1543

Andreas Vesalius publishes his series on the human body, which acts as a catalyst for the end of Galen's domination over medical thinking. Looking at the body layer by layer, in meticulously crafted pages, Vesalius mapped out the bones, muscles and ligaments, veins, arteries, nerves and organs. Observational science takes over as a new way of thinking and the beginnings of modern biology are born.



1745

Medical school
Henry VIII founds the Royal College of Physicians in London. After 1523, the esteemed college would be responsible for managing the licenses of medical practitioners throughout England.
1518

The Great Surgery Book
Paracelsus publishes *Die Grosse Wundartznei* (*The Great Surgery Book*), firmly establishing his reputation in medicine and enabling him to better pursue his theories on toxic substances.
1536

A new theory
Girolamo Fracastoro proposes his theory of the spread of disease through spores with *On Contagion*, which remained influential until the advent of germ theory and began to replace a fear of noxious miasma.
1546

The king is dead
Henry VIII dies, spending his last days weak from the pain of his erupting ulcers and mad with fever. He passes the throne on to young Edward VI, just nine years of age.
1547

Back to black
The Black Death strikes again, killing more than 30,000 people in London. The next, and final, outbreak of the plague will be in 1665, at which point Yersinia pestis would finally fade into history.
1603

Surgically removed
Surgeons decide to split from barbers once and for all by forming their own Company of Surgeons, which would go on to become the Royal College of Surgeons in 1800.
1745

© Alamy, Abi Daker, Getty Images

1632

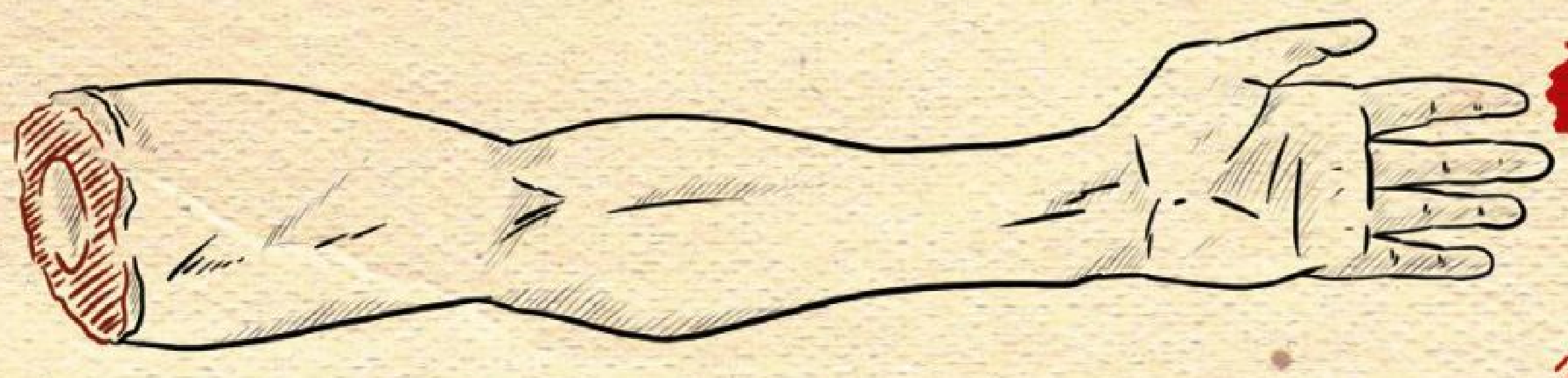
LESSON IN HUMAN ANATOMY

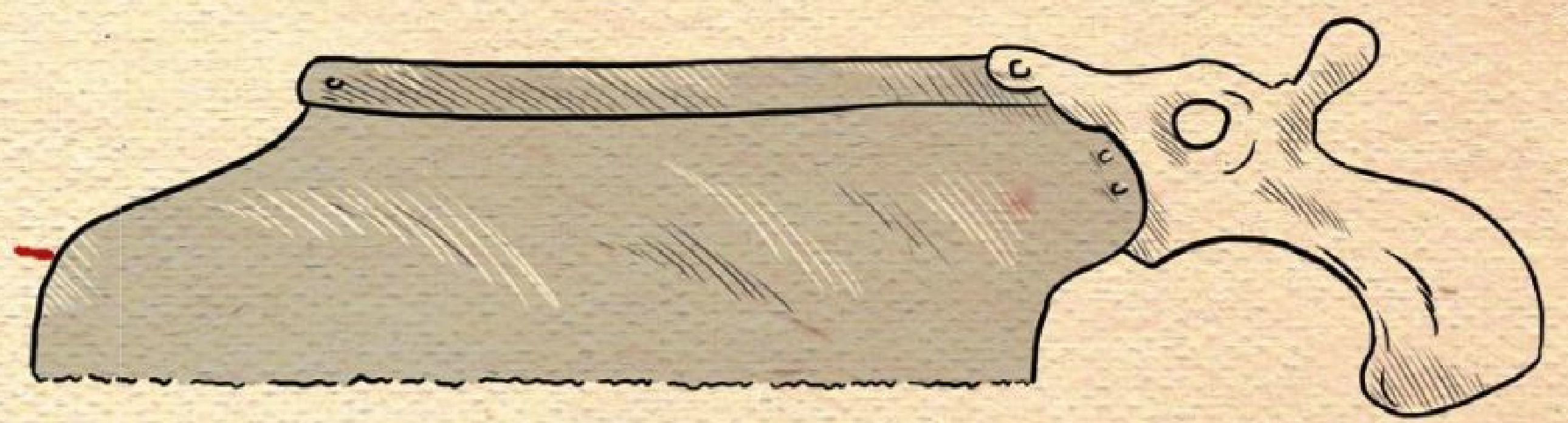
1632

Dr Nicolaes Tulp, a Dutch surgeon from the Netherlands, teaches a group of students about human anatomy in the Hague. Tulp was a very well respected doctor and was the subject of this painting by Rembrandt, titled *The Anatomy Lesson of Dr Nicolaes Tulp*. Along with some of his fellow chemist and doctor friends, he set about writing the first pharmacopeia of Amsterdam, the *Pharmacopeia Amstelredamensis*.

© Getty Images

WELCOME TO THE EMPORIUM OF MARVELLOUS Victorian Medicine





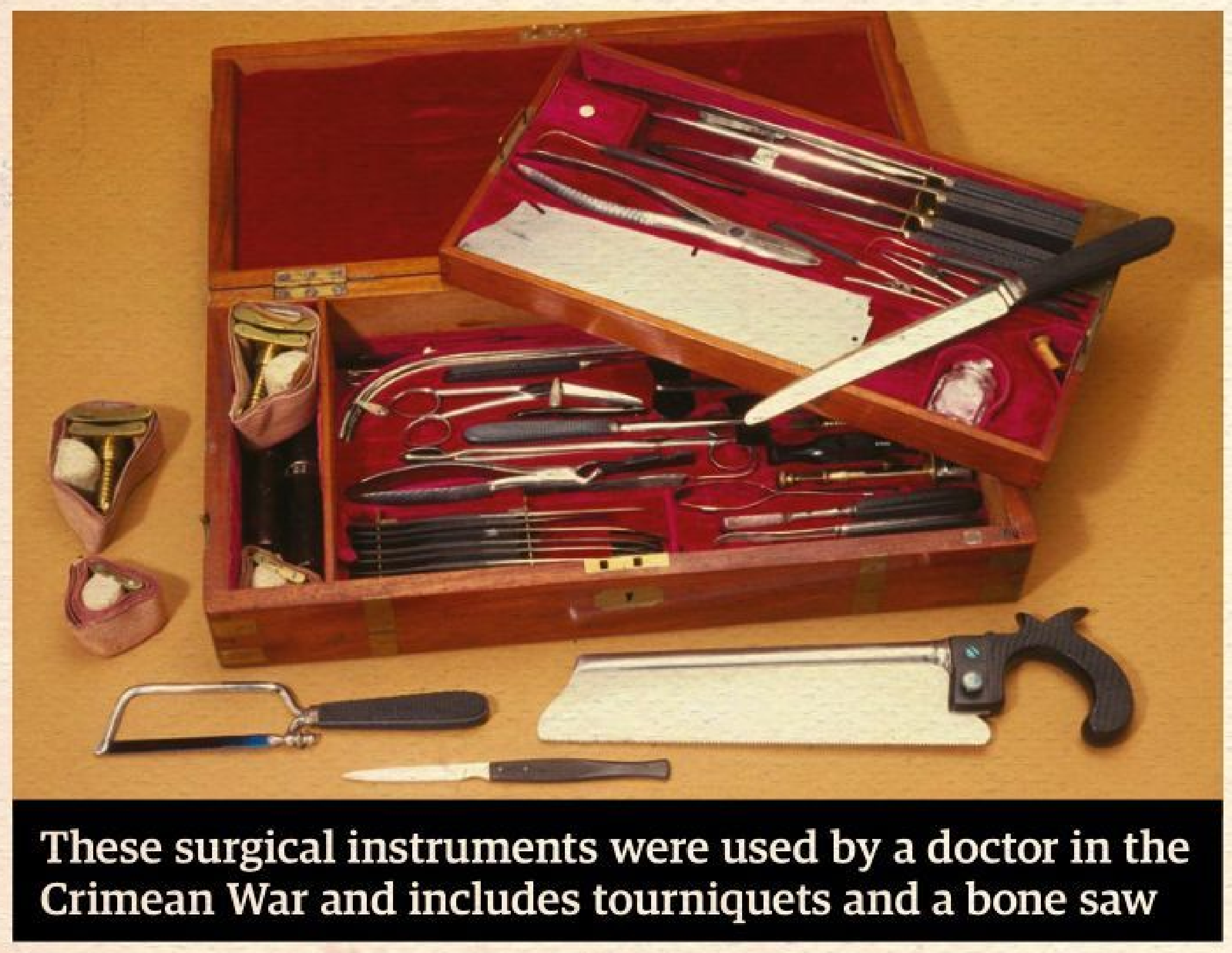
Brace yourselves as we delve into the dangerous world of deadly diseases and even deadlier treatments. The doctor will see you now

Written by Jodie Tyley

Florence Nightingale was a leading figure in improving battlefield medical practices

Ask any Victorian doctor and he will tell you, the best way to fend off an illness is to take a healthy dose of mercury, arsenic or wine mixed with Class-A drugs. In the 1800s, the remedies have the same outcome as most of the diseases: an early grave.

Death was so common that many people were buried by the time they were 20. Mortality rates were particularly high in the cities, where the Industrial Revolution and the invention of the steam engine saw factories spring up all over London. People packed their bags and left the countryside in search of opportunity. What they found was a desperate need for more housing.

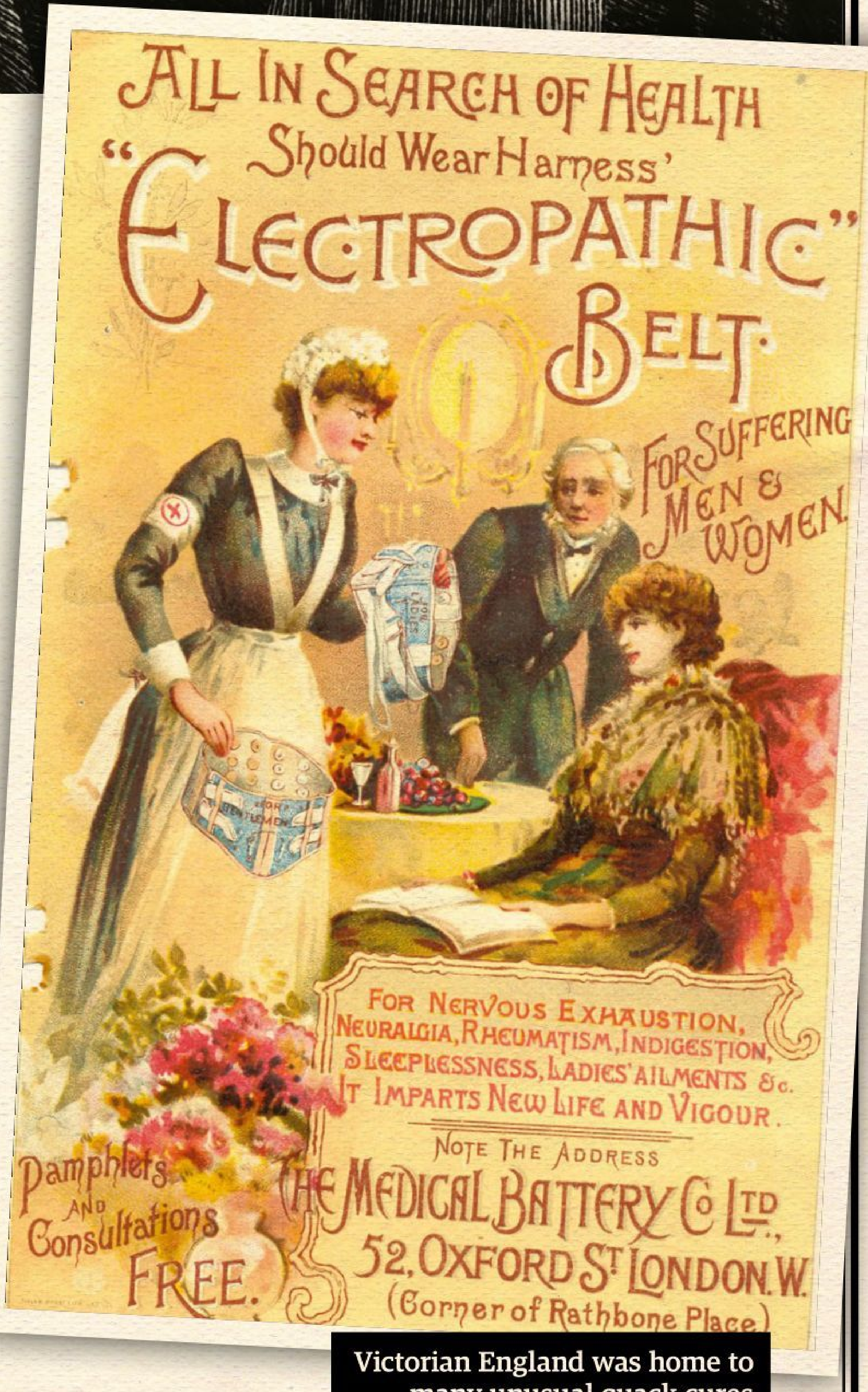


These surgical instruments were used by a doctor in the Crimean War and includes tourniquets and a bone saw

Many were forced to live in cramped conditions, close to filthy rivers and smoke-belching factories. This led medical practitioners to believe that a lungful of sea air would cure most maladies, along with laxatives, bleeding and then - with the advent of electricity - new and unsettling treatments were born. This bred a fear of science among the general populace and helped inspired Mary Shelley's Gothic tale *Frankenstein*. The horrors didn't end there.

Surgeons needed bodies in order to understand the human anatomy, but executed criminals were the only legal source of cadavers. When these became scarce, the body snatchers moved in, robbing the graves of the recently deceased. New depths of depravity were reached when Edinburgh 'resurrectionists' known as Burke and Hare began killing the living to sell the bodies. They murdered at least 16 people before being brought to justice.

Much of medicine was down to guesswork, and students underwent very little training. Even barbers would pull teeth and practice bloodletting. This gruesome side venture is said to be represented by the traditional barber pole - red for blood, white for bandages. But for every quack cure, there was a scientific breakthrough that would help the progression of diagnosis and cure. By the end of the century there were microscopes, anaesthesia and the X-ray, ushering in a new era of medicine - one that couldn't come soon enough.



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Victorian England was home to many unusual quack cures

Victorian hospital wards were crowded and disease ridden

HIDDEN HORRORS OF LONDON

Visit the capital of cholera and try the special sewage water. It's to die for

"What are those papers floating down the river?" asked Queen Victoria during a visit to the city of Cambridge. The grim reality was that raw sewage flowed into the water and it was actually some used lavatory paper that had caught her eye. "Those, ma'am, are notices that bathing is forbidden," came the quick-witted reply.

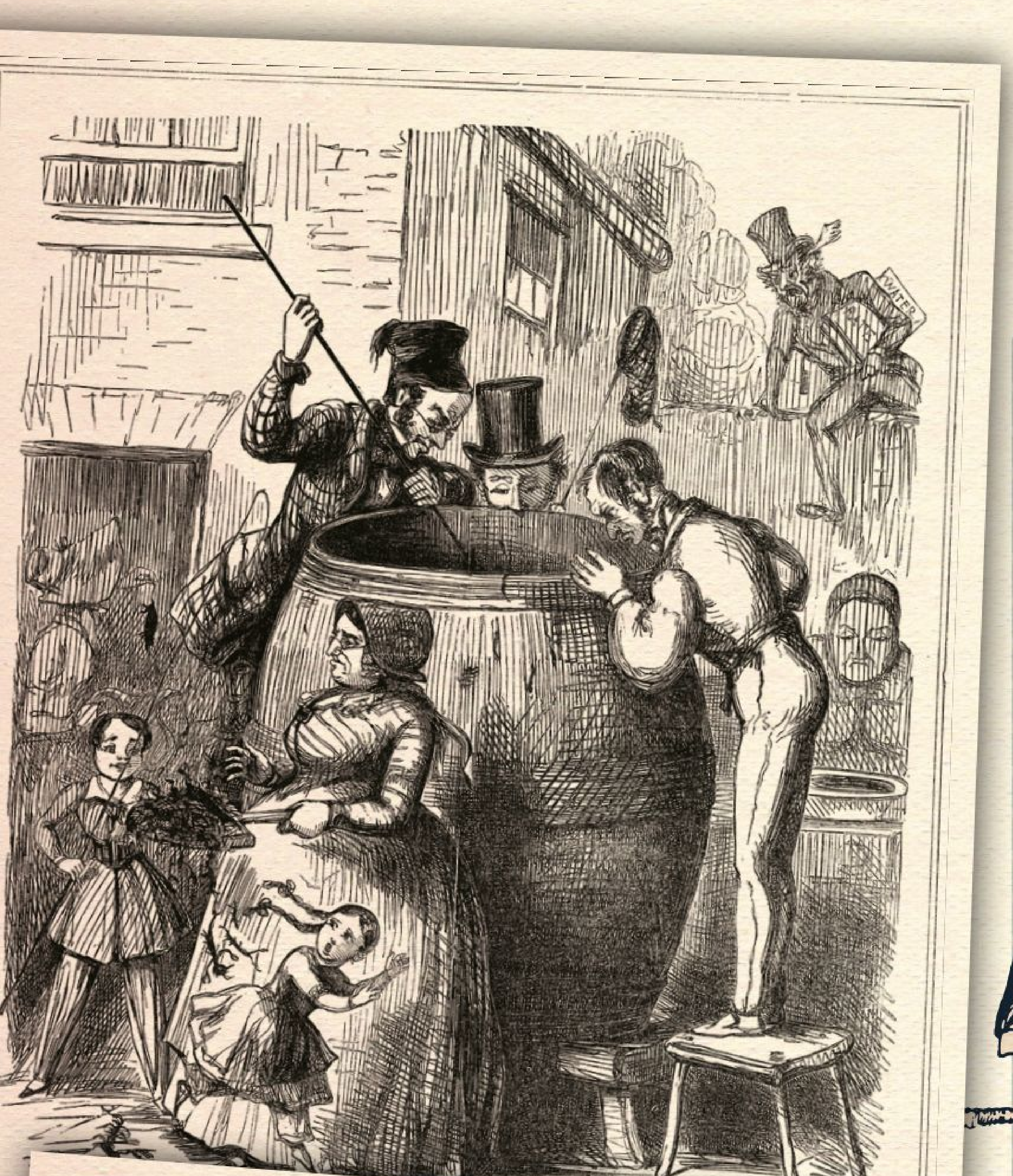
In those days, the only sewerage systems were the rivers and streams that would carry the contents of chamber pots, debris and the occasional corpse into the sea. The system had worked for a while, but London was no longer the tiny Roman settlement that it once was. It was now a sprawling metropolitan city, bristling with industry and buckling under an ever-growing population that relied upon water pumped from the River Thames as its source for drinking, washing and cooking.

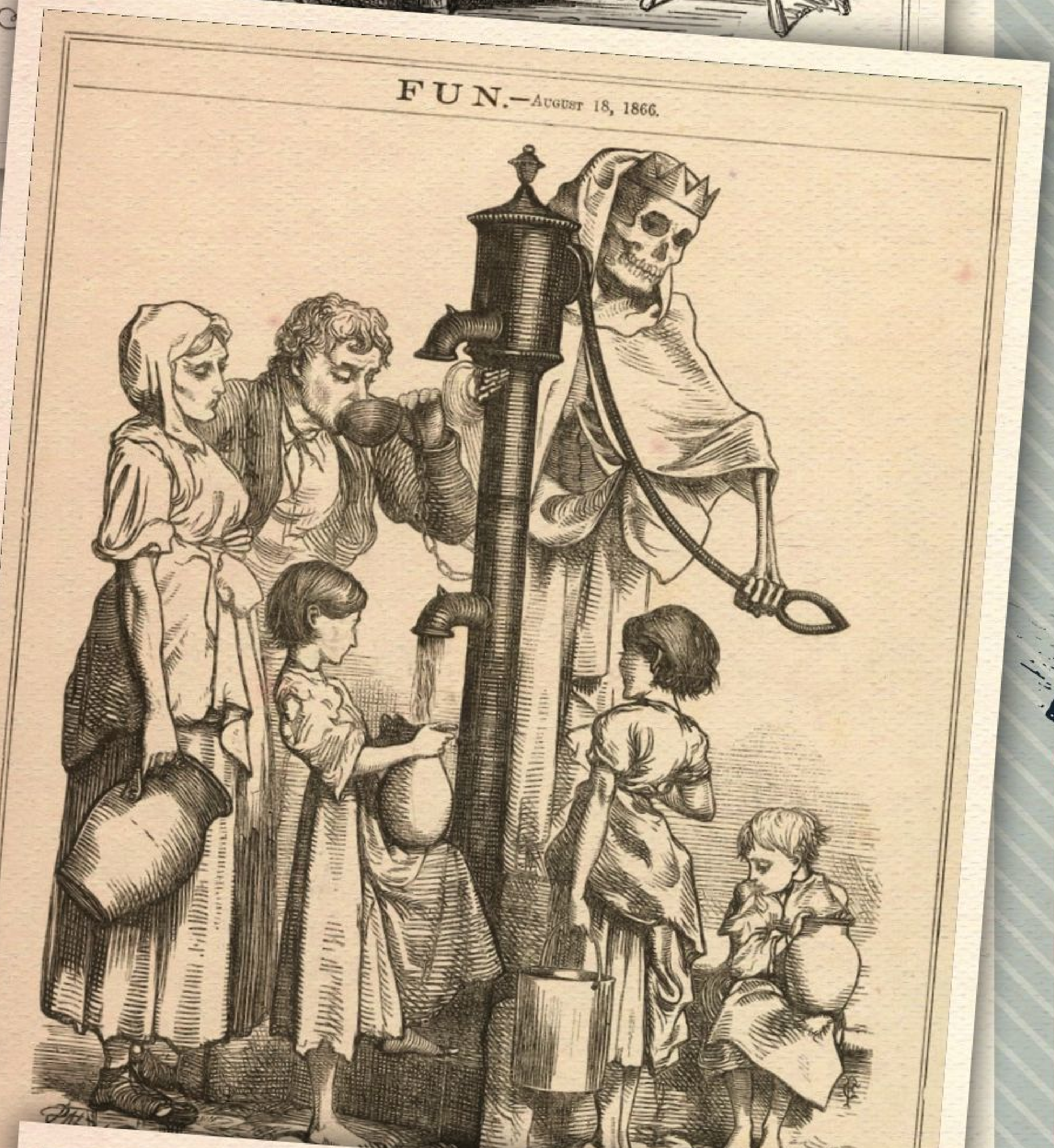
Disease was inevitable, and a severe outbreak of cholera claimed the lives of more than 14,600 in 1849. Victims were beset by retching, diarrhoea and excruciating cramps and would die within hours. Many thought the disease was transmitted through bad air, called miasma, and tried to ward it off with smelling salts. It was a truly frightening time, inspiring some of the first investigations into living conditions and spurring on the development of public health.

But physician Dr John Snow had his own theories about how cholera spread. He was busy researching the relationship between water supply and deaths when the disease returned to London in 1854, and he noticed how this time it seemed to centre around one water pump in Soho's Broad Street. The only people spared were the men working in the local brewery, simply because they drank the beer, not water! Snow managed to convince town officials to take the handle off the contaminated pump and, sure enough, the disease began to dry up.

Despite this, the Board of Health refused to take any further action. They didn't believe the sewage could leak into the water pumps, even though 400,000 tons of stinking mess were released into the River Thames every day. The volume was overwhelming, and in 1858, a particularly hot summer brought the city to a standstill in what was called the Great Stink. This time, action was unavoidable, and the MPs met in the Houses of Parliament to discuss a plan. Not before the curtains were doused in chloride of lime, however, to keep them from choking.

A programme of sewer building was ordered and this, ultimately, banished cholera for good. The disease would return one last time, but only in an area that had not yet been connected to the new sewers. The Public Health Act in 1875 established a state system of medicine that oversaw housing, water supply and sewage and drainage, helping to prevent contagious diseases and future outbreaks.




FUN.—August 18, 1866.

Embarrassing Victorian bodies

Dr Crippin tackles your queasy questions and miserable maladies

Please Sir,
I have bin up all nite with the most awful aches, pains an I got such a horrid cold sweat that won stop. I daren't not turn up for work tomorra, but I needs to sweep the chimneys, or else the master swares he will light a fire right unnerneath me!
John, aged 7

You are suffering from typhus, and I know just the thing to cure you: blistering. It's the latest medical technique – simply scald the skin with hot pokers in order to burn away the illness. With your profession, however, you will soon choke and suffocate from inhaling chimney dust anyway, so perhaps your best bet is to pray twice daily.

Dear Dr Crippin,
During a delightful afternoon tea, one started to cough and perspire in a quite unladylike manner, sending frightful lumps of scone flying all over the tablecloth. My companions were terribly vexed and I fear I shall never be invited back again. Now one is sporting the most unbecoming rash! How much longer must this gross humiliation be tolerated?
Anonymous and Concerned Society Lady

My dear lady, you have a case of the measles and must sweat the poisons from your body at once. Wrap yourself in blankets and when you're saturated with perspiration, ask a servant to douse your body in cold water and massage the skin. Most importantly, send a note of apology to your hostess.

Dearest Dr C,
I awoke last night to my husband staggering through our front door, then holding an incomprehensible conversation with our grandfather clock. He then fell to the floor, asleep on the spot, and has been horizontal for 24 hours. He reeks of the foulest substances and I fear the opium den is to blame. What should I do?
Middle_Classy_1841

When someone has passed out from too much drinking – or smoking – you must pour vinegar down their throat and rub it on their temples. Then prepare a drink of Peppermint Water (iron sulphate, magnesia, peppermint water and nutmeg), or warm milk mixed with ashes from the fireplace. Your poor husband will be smoking a pipe and reprimanding the servants in no time!

Dr,
I'm a sailor back on shore leave from Her Majesty's navy, where we was living off a diet of salted beef and old stale biscuits for months on end. Just between us, my bowels haven't dropped anchor in weeks an' me shipmates reckon I've been cursed. What can you suggest to get the wind back in me sails?
Yours,
Bunged-up Billy Wantloose

If your body's natural 'flow' is in choppy waters, you can take a simple blue pill, containing a large dose of the poisonous – I mean *purifying* – ingredient mercury. Did you know that the American President Abraham Lincoln used the very same medication? Wash it down with black draught, which will remove any obstructions and ease evacuation. You'll find an exceedingly good recipe in *Mrs Beeton's Book Of Household Management*.

QUACK CURES

If the symptoms didn't kill you, the treatment might

In Victorian times, it was possible to stroll into a chemist and buy cocaine, morphine and even arsenic over the counter. In fact, people were practically shoved through the door by the pushy adverts that claimed they worked miracles. There were no regulations at the time, and Class-A substances were cheap. No one tested whether they stood up to their claims, and if people became addicted to the so-called magical ingredients, then that was excellent news for business.

Morphine Soothing Syrup

You'll never climb the social ladder with a teething toddler in tow! Halt their suffering with a spoonful of Soothing Syrup. Morphine will soften the gums and ease them into a deep slumber. Also relieves wind and regulates the bowels.

Heroin Cough Elixir

Cease that hacking and gagging at once with the herbal cough killer that's chemist recommended. Unlike morphine, heroin is not addictive* and will leave you in curiously good spirits for the rest of the day.

**Actually four times stronger than morphine*

French Tonic Wine

Liver disease getting you down? This spectacular tonic from Bordeaux has two key ingredients for getting you back on your feet: alcohol and cocaine. The all-natural remedy will transform you into the picture of health. Drink daily to strengthen your body and mind.

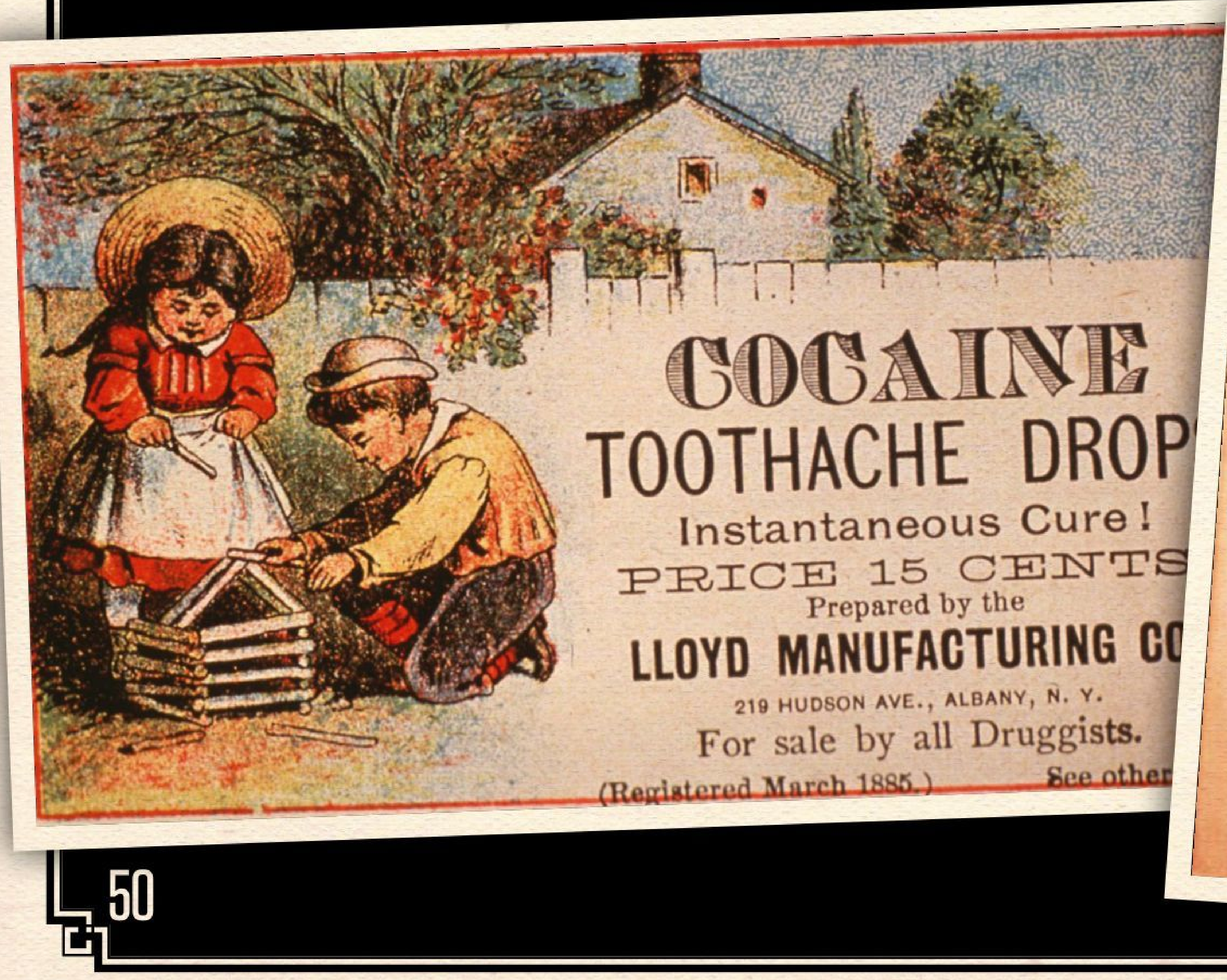
Cocaine Toothache Drops

If your cavities are causing you grief, a trip to the dentist will lead to extraction, infection and probably death. Put a smile back on your face with this spectacular cure, giving you instant pain relief. It tastes delicious and is suitable for all ages.

Leeches

Banish bad blood and impurities with your friend the leech. All that's needed is one small incision and the little sucker will do the rest. When it's well fed, it will drop off, leaving you disease free.

Side effects may include fainting, bleeding for days and breathing difficulties.



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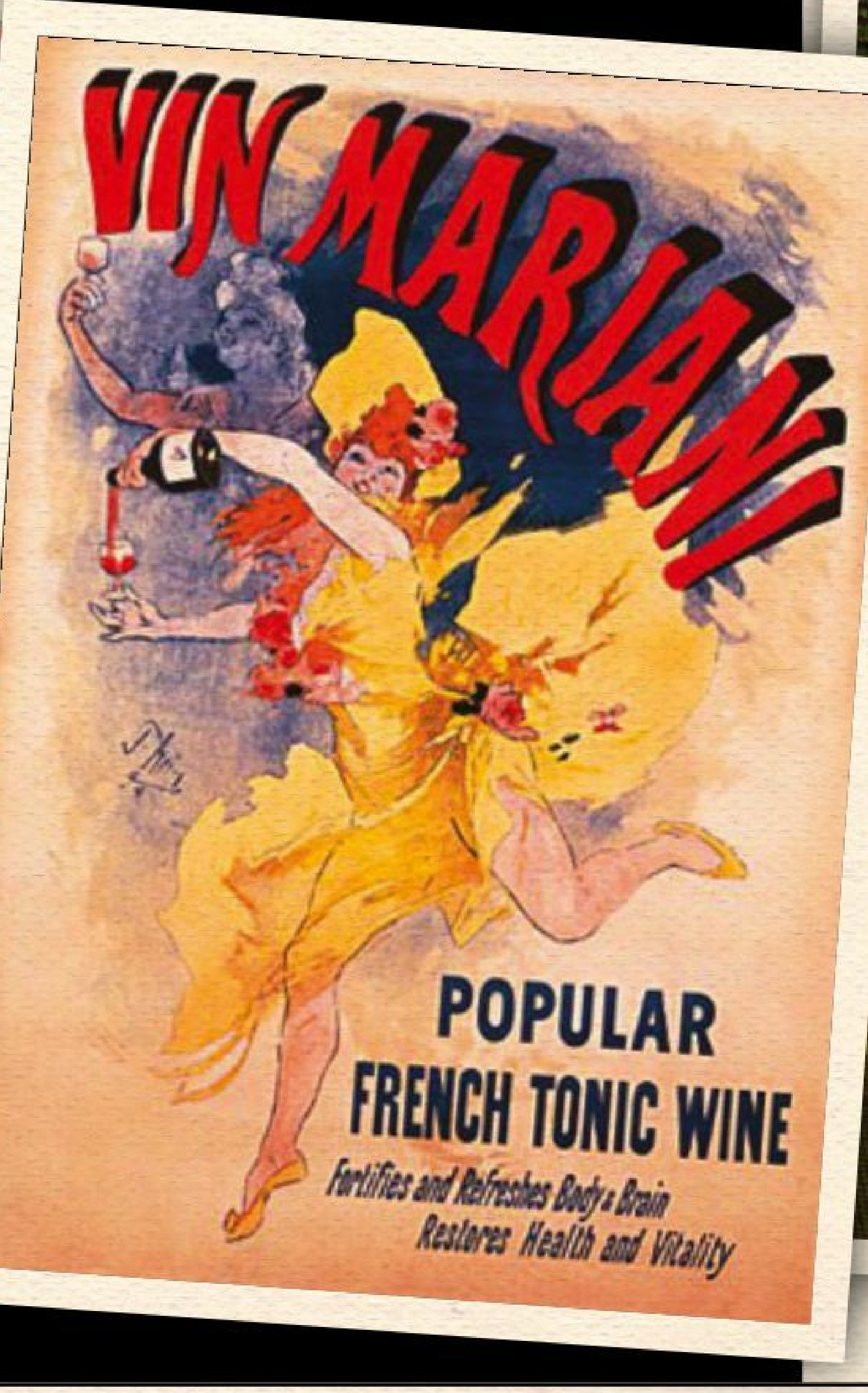
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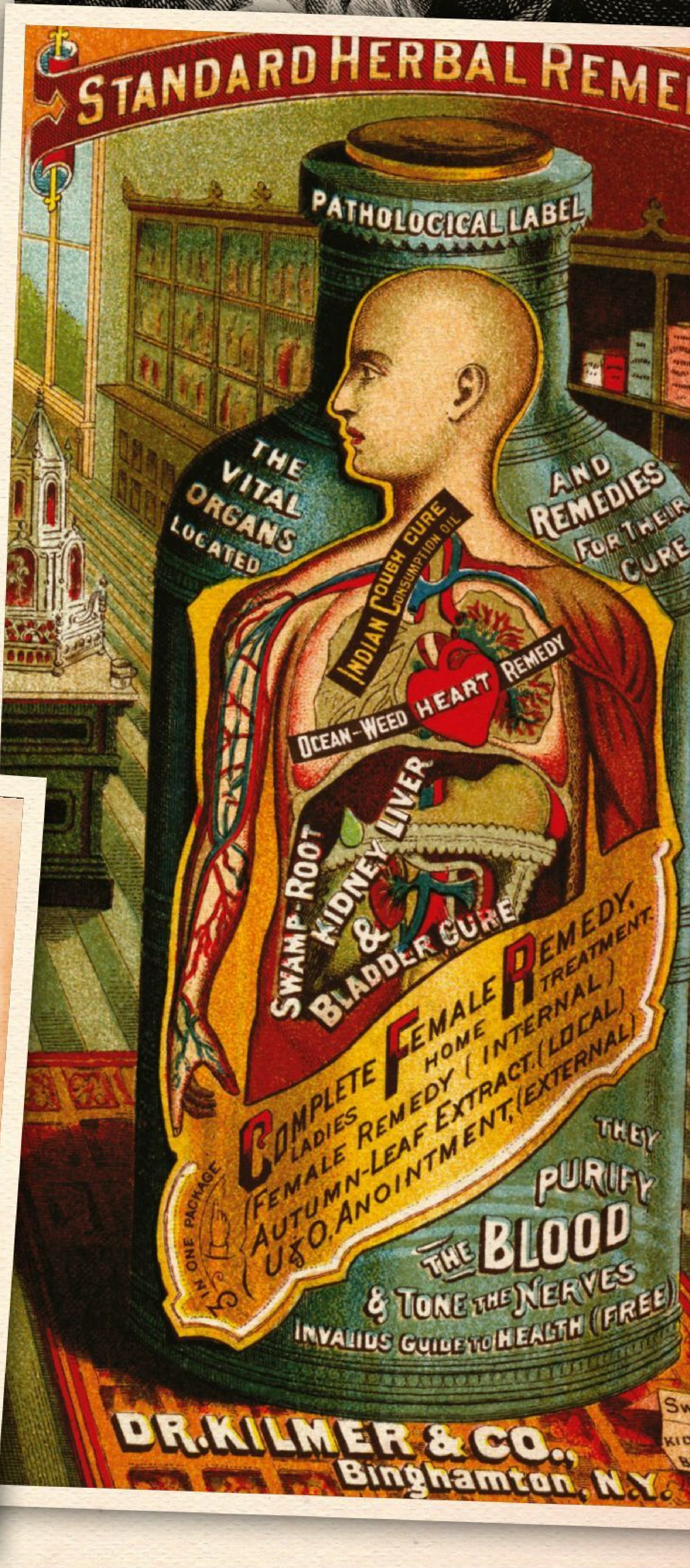
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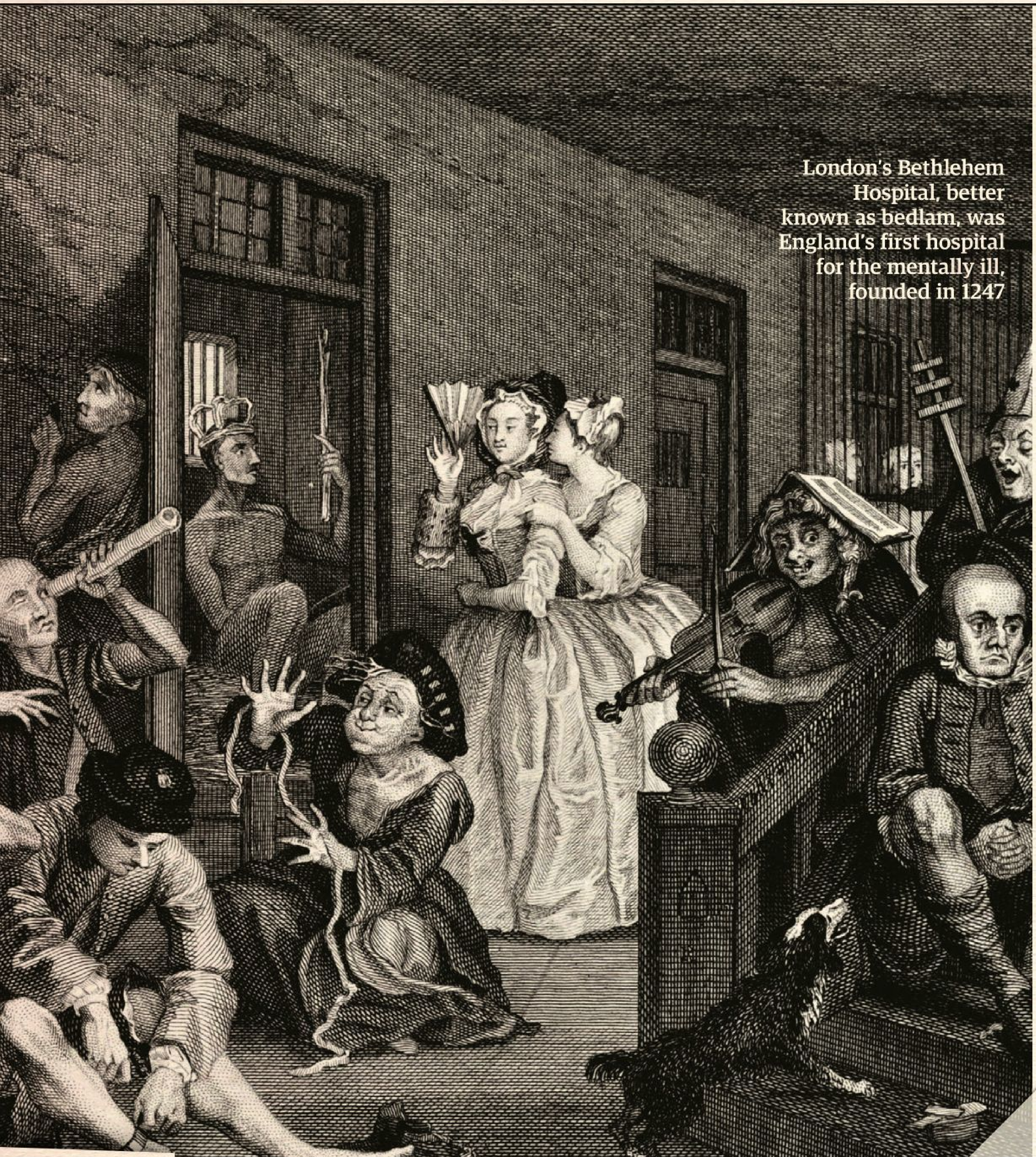


London's Bethlehem Hospital, better known as bedlam, was England's first hospital for the mentally ill, founded in 1247

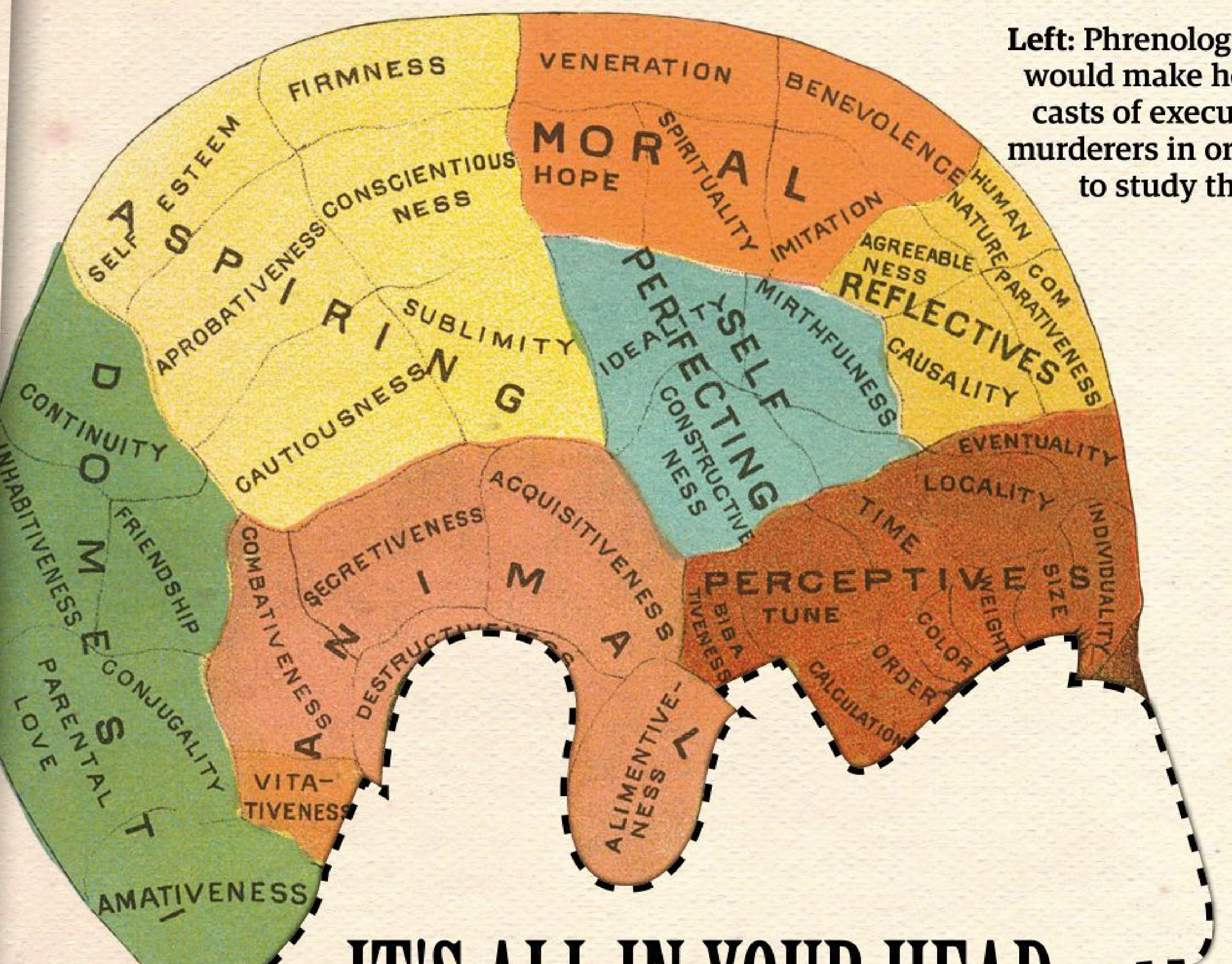
INSIDE THE INSANE ASYLUM

Shackled and sedated, these so-called safe havens were truly terrifying

In the early days of Queen Victoria's reign, it was pretty easy to get rid of inconvenient people. Wealthy families eager to get grandmother out from under their feet could admit her to any one of the private madhouses dotted around the country. They would pay the doctor to write a certificate of lunacy and thugs would come to abduct her. It was a profitable business so there was no incentive to release patients or help them.

As a result, straightjackets and sedatives were prescribed to completely sane people, but these scandals paled in comparison to the filth and neglect of public asylums. It wasn't until the government enforced regulations in 1845 that the system was marginally improved, with doctors having no affiliation with the asylums that they committed people to. Despite this, patients were still subjected to overcrowded wards and treated as guinea pigs for new and frightening medical procedures.

One of these, the lobotomy, involved severing part of the brain tissue. It was believed that this separated the emotional centre from the intellectual part. Clearly, the mind was still a mystery to Victorian medical professionals and they would record the incident that led to the patient's incarceration as the cause of illness. Looking back at what they considered to be mental illness seems morally insane today.



Left: Phrenologists would make head casts of executed murderers in order to study them

IT'S ALL IN YOUR HEAD

Victorians thought you could tell everything about a person by the shape of their skull

Phrenology was the belief that the shape of someone's head could reveal their character traits. It was thought that the brain was made up of many organs, and that the skull mirrored their functions. By feeling the bumps on their noggins, phrenologists claimed to know people's strengths and weaknesses, their moral and religious beliefs, and more. People would queue up to have their heads read for guidance in life and love. Even the great inventor Thomas Edison said: "I never knew I had an inventive talent until phrenology told me so. I was a stranger to myself until then."

BY REASON OF INSANITY

Four ways you could be locked up in the madhouse

Talking back
Women's suffrage was still a century away, and any woman who dared to refuse a life of domesticity could be declared insane by their husband or father and shipped to the madhouse.

Depression
Those grappling with post-natal depression were treated with electroconvulsive therapy – passing a current through the brain and inducing an epileptic fit.

Hysteria
Physicians considered women the weaker sex and more susceptible to nervous breakdowns. This was the main reason asylums often had far more female patients.

Spinsters
Women who did not choose to live the conventional Victorian lifestyle were considered a threat to society. Without male interaction, they were classed as mentally ill.

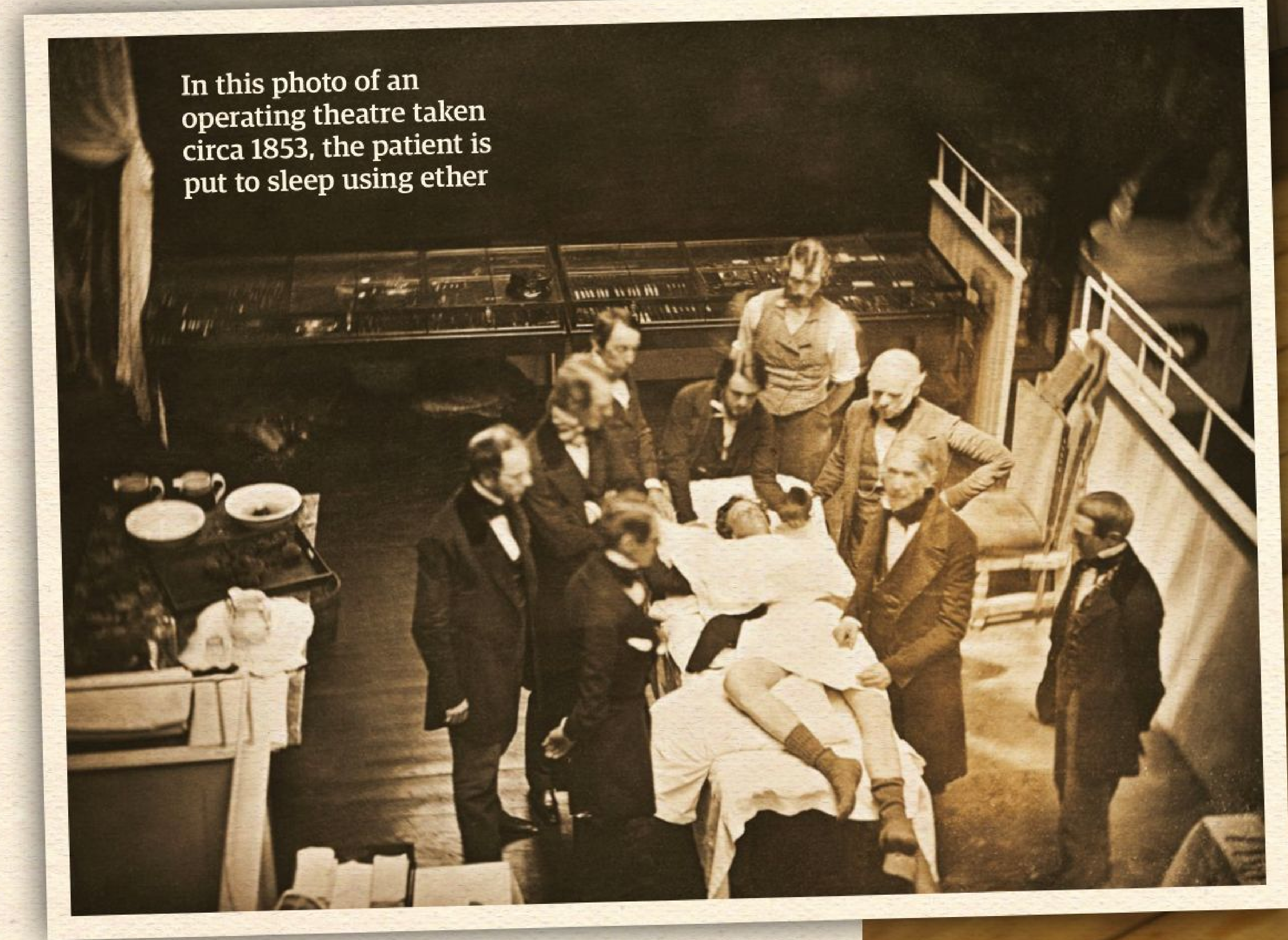
ON THE OPERATING TABLE

Experience the nightmare of a typical surgical procedure

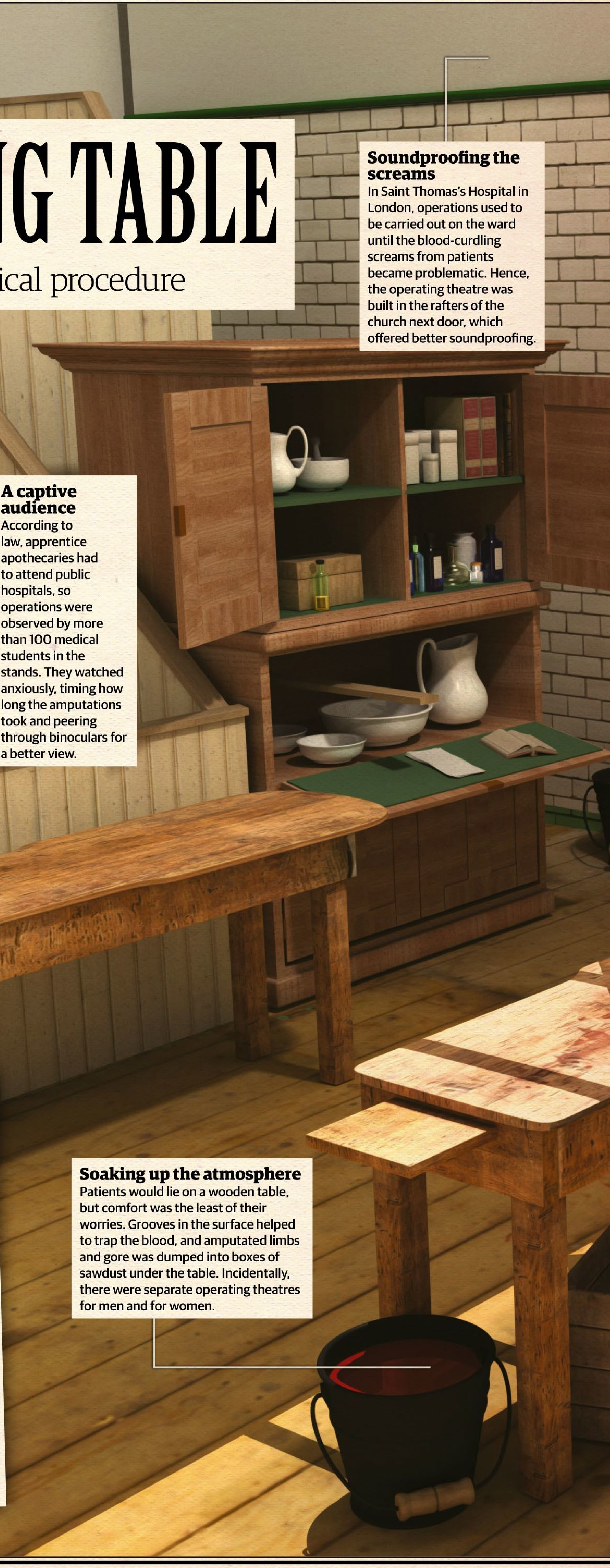
A gentleman lies on the wooden operating table, feeling the throbbing of his broken leg and the weight of 100 stares. The viewing gallery is filled with medical students, anticipating the arrival of the surgeon and a performance everyone will remember. A door opens and men dressed in blood-encrusted aprons troop through. Two of them - called dressers - grip the man's shoulders and one of them warns: "If you should jerk, or even stir, you will do it at the hazard of your life."

The surgeon plucks his favourite ebony-handled knife from a case of torturous looking implements and shouts: "Time me, gentlemen!" With a flash of blade and flesh, he tosses the leg aside in less than 60 seconds. Applause mingles with the screams of the fully conscious patient. With anaesthetic yet to be invented, it's crucial that the procedures are carried out as swiftly as possible. For this reason, operations were restricted to amputations and any limb with a fracture that pierced the skin would have to be removed.

Sir Robert Liston was one of the finest surgeons of his day - only one in ten patients died on his table. He worked so quickly that, according to urban legend, he once sliced off a man's testicles along with his leg by mistake. Liston, however, made the history books not for his ballsy approach, but for trialling anaesthetic in the UK for the first time. An American dentist had invented a curious mixture of alcohol and sulphuric acid to knock out his patients, and Liston was to do the same. With no struggle, the operation took just 25 seconds and when the patient awoke, he reportedly asked when it was going to begin. It was the start of the development of anaesthetics, and the dawn of modern surgery.



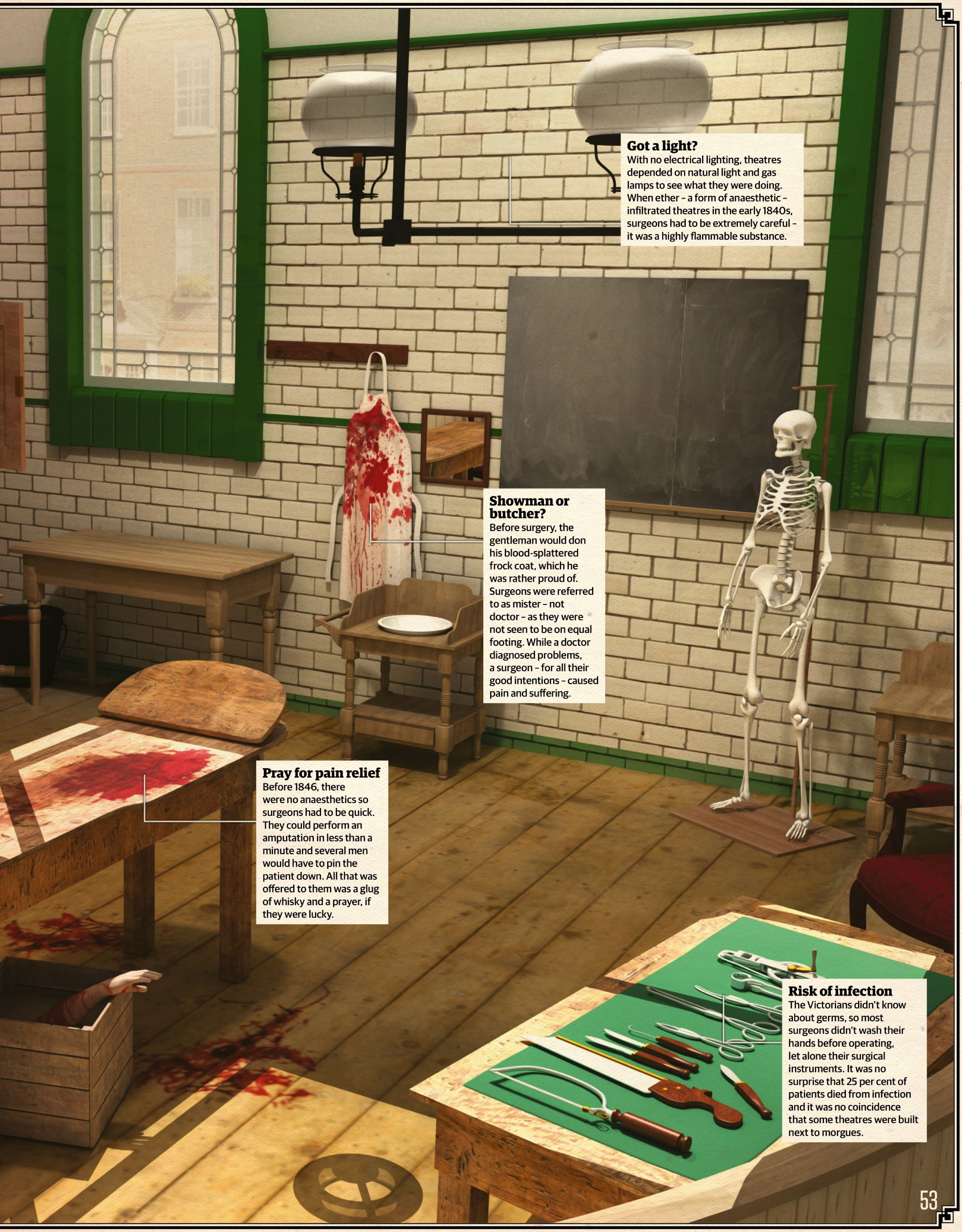
In this photo of an operating theatre taken circa 1853, the patient is put to sleep using ether



Soundproofing the screams
In Saint Thomas's Hospital in London, operations used to be carried out on the ward until the blood-curdling screams from patients became problematic. Hence, the operating theatre was built in the rafters of the church next door, which offered better soundproofing.

A captive audience
According to law, apprentice apothecaries had to attend public hospitals, so operations were observed by more than 100 medical students in the stands. They watched anxiously, timing how long the amputations took and peering through binoculars for a better view.

Soaking up the atmosphere
Patients would lie on a wooden table, but comfort was the least of their worries. Grooves in the surface helped to trap the blood, and amputated limbs and gore was dumped into boxes of sawdust under the table. Incidentally, there were separate operating theatres for men and for women.



Got a light?

With no electrical lighting, theatres depended on natural light and gas lamps to see what they were doing. When ether – a form of anaesthetic – infiltrated theatres in the early 1840s, surgeons had to be extremely careful – it was a highly flammable substance.

Showman or butcher?

Before surgery, the gentleman would don his blood-splattered frock coat, which he was rather proud of. Surgeons were referred to as mister – not doctor – as they were not seen to be on equal footing. While a doctor diagnosed problems, a surgeon – for all their good intentions – caused pain and suffering.

Pray for pain relief

Before 1846, there were no anaesthetics so surgeons had to be quick. They could perform an amputation in less than a minute and several men would have to pin the patient down. All that was offered to them was a glug of whisky and a prayer, if they were lucky.

Risk of infection

The Victorians didn't know about germs, so most surgeons didn't wash their hands before operating, let alone their surgical instruments. It was no surprise that 25 per cent of patients died from infection and it was no coincidence that some theatres were built next to morgues.

Nightingale was nicknamed the Lady with the Lamp after making solitary rounds of the sick long after the medical officers had gone to bed

FRONTLINE MEDICINE

How the terrors of the Crimean War and a self-trained nurse propelled medical advances

Even in the 17th century the need to provide aid to wounded and sick soldiers was well understood, but it would be 200 years before technology and science saw the rise of battlefield medicine. Among the most important developments in the mid-19th century was anaesthetic, primarily used for the grisly amputation of limbs in field hospitals. Whereas before a wounded soldier could expect his damaged limb to be hacked away with the surgeon's rusty saw – while he could only look on in excruciating pain and bite down on a rag for respite – with the use of chloroform he would be sent into a senseless sleep for the entire terrible procedure. However, this new medicine did not come without risk. Experimental anaesthetists could easily over-administer their wonder drug and find themselves performing an autopsy on their patient, rather than a life-saving procedure.

This risk carried with it widespread suspicion among the medical community. At the beginning of the Crimean War in 1853, the British Army's Principle Medical Officer, John Hall, wrote that "the smart of the knife is a powerful stimulant, and it is much better to hear a man bawl lustily than see him sink silently into the grave." Regardless, the practice of using anaesthesia on wounded men increased throughout the war, and with it better practices were learned and publicised in medical journals such as the *Lancet*. In particular, French army medics administered only very light anaesthetics to their patients, accompanied by swift procedures so that the patient would not awake prematurely.

Hygiene standards and practices in military field hospitals were also overhauled during the conflict, most famously by Florence Nightingale. After visiting a field hospital in Scutari, she noted that men were left unattended for weeks, in quarters infested with rats and lice. With only a small number of chamber pots between up to 1,000 patients, disease also spread quickly through the hospital, claiming yet more lives miles from any battlefield. After returning to London, her findings shocked many in the government and the general public, and the desperate need for better organised medical services in the army was recognised.

Medical milestones in the war zone

1847

The Royal Navy adopts anaesthetic

While serving in a Royal Navy hospital in Malta, surgeon Thomas Spencer Wells records administering anaesthetic to 106 patients suffering with varying wounds and ailments – this is the first time that ether is used in the British armed forces.

1853-56

The Crimean War

At the outset of the Crimean War, the British Army suffers terribly from disease and exposure to the harsh Russian weather. Anaesthetic is used widely by French, Turkish, Russian and British armies, though initially the administration of heavy doses often kill patients outright. By the war's end, a much better understanding of the use of chloroform for operations has developed.

1857

Military medical reforms begin

After observing the terrible conditions wounded soldiers experienced on the front line, Florence Nightingale instigates a royal commission to investigate the health of the army and its medical practices. She later founds the Nightingale Training School for nurses. Graduates from the school would go on to be called 'Nightingales'.

1863

First army medical school

Aided by Florence Nightingale, the first permanent military hospital and Army Medical School is established in Hampshire. Here, civilian doctors and nurses are trained to serve in the army, alongside research and development into hygienic medical practices for use on the battlefield.

1881

Army Nursing Service started

The first official military nursing body is organised, and nurses (called Sisters) are dispatched to the front line of the Zulu War (1879) and the Egyptian Campaign (1882). By 1883, every military hospital that has 100 beds or more is staffed by Sisters of the Army Nursing Service.

1897

Typhoid vaccine developed

While working at the Army Medical School, Almroth Wright develops the first vaccination for Typhoid fever, a preventable disease that often killed thousands of soldiers in the period. Though the vaccine is at first resisted by army officials, by the 20th century it is widely administered to serving soldiers.

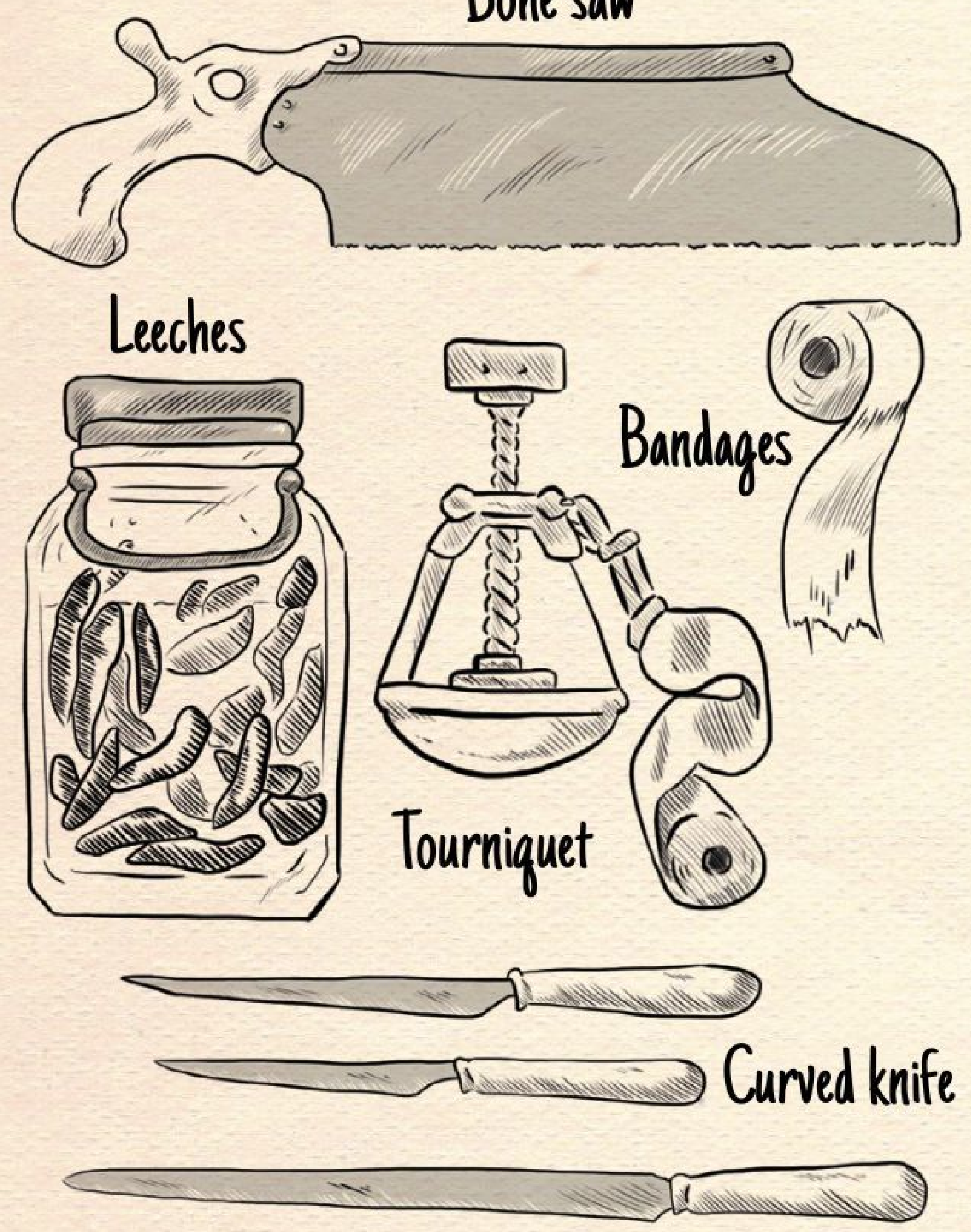
1898

Royal Army Medical Corps founded

An official medical wing of the British armed forces is created, under which serving medical military personnel are granted the official ranks, pay and privileges of the regular army. The new Royal Army Medical Corps first sees action during the Second Boar War (1899-1902).

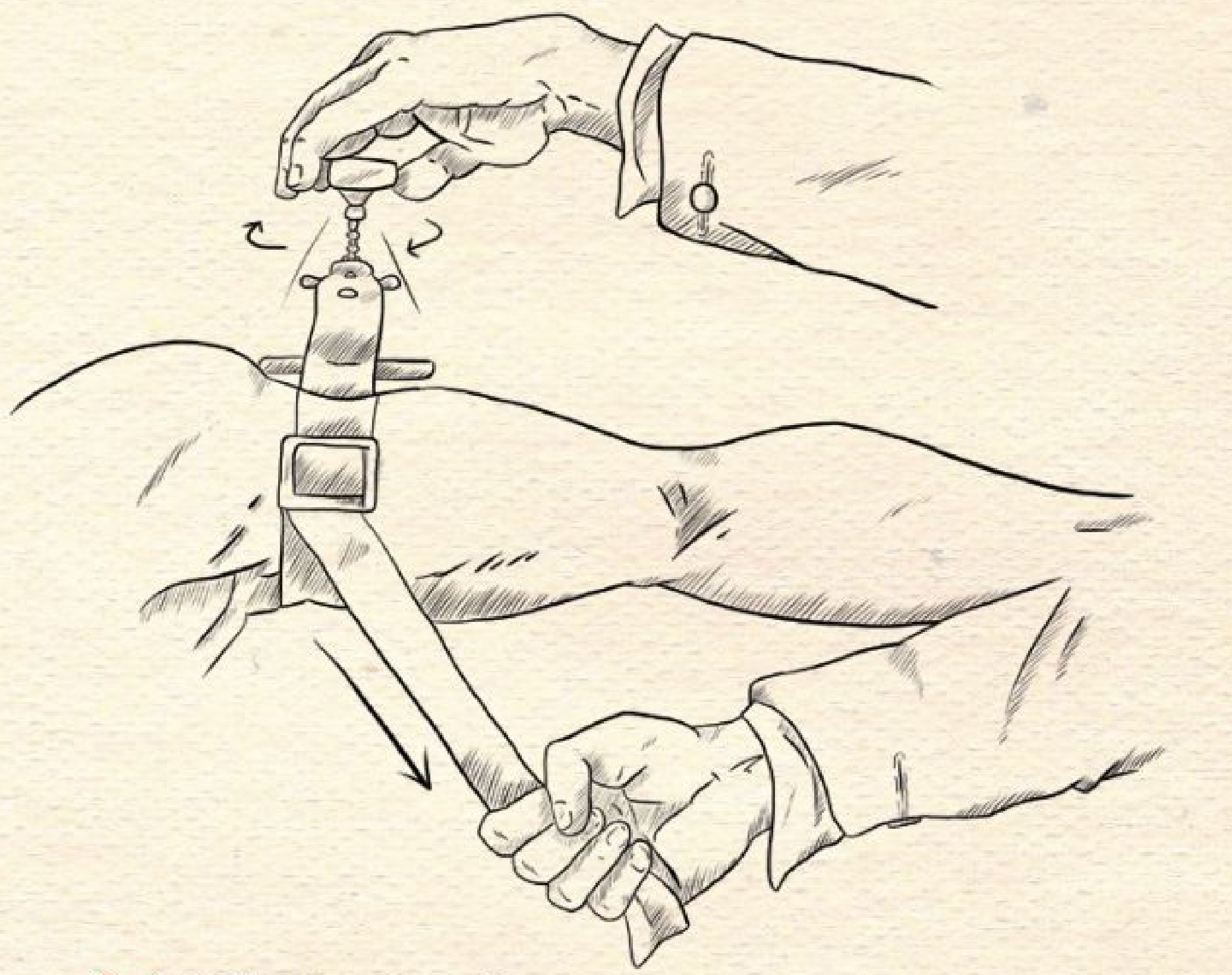
BEGINNER'S GUIDE TO AMPUTATION

How to remove infected limbs without anaesthetic



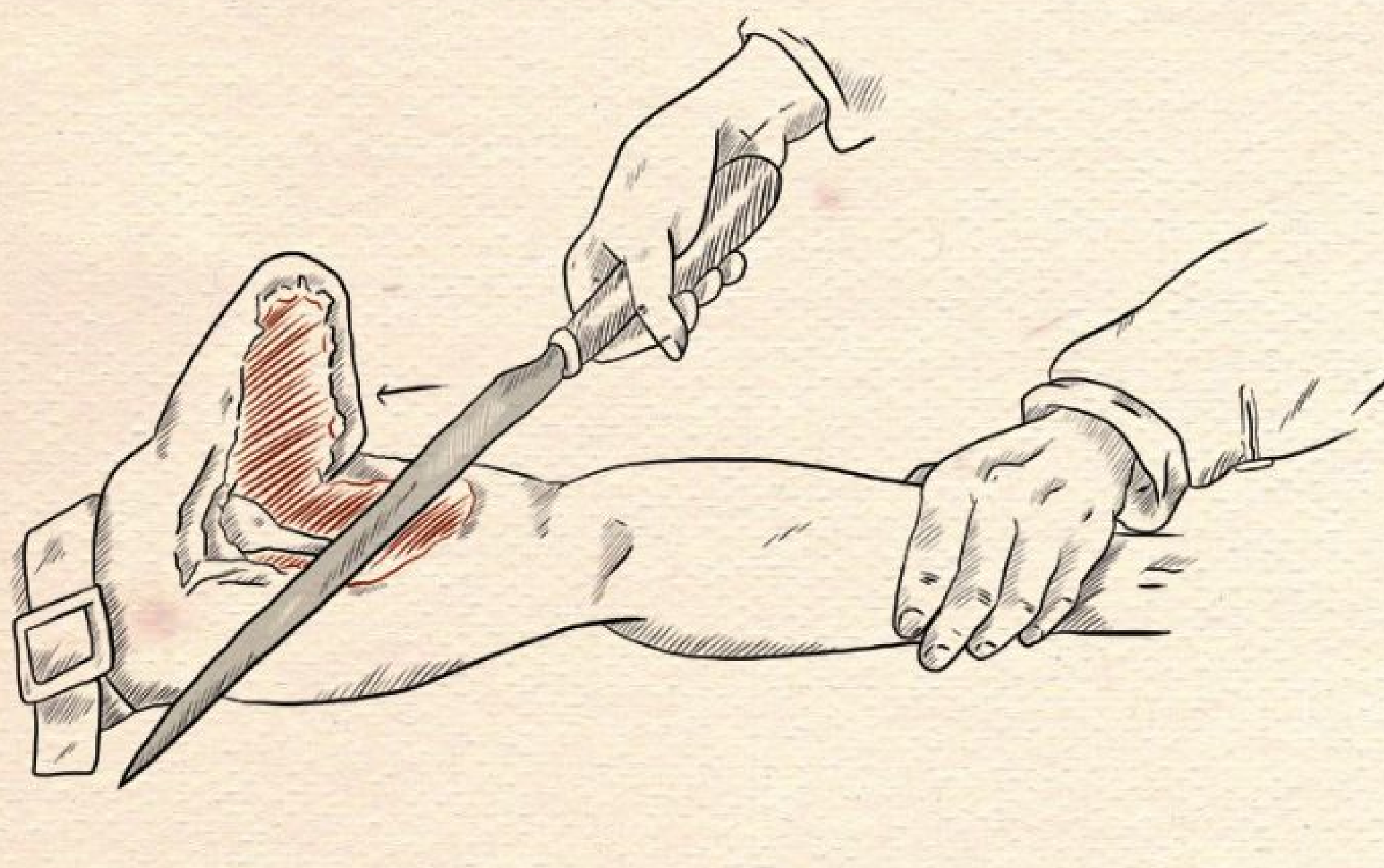
Step 01. Prepare your patient

Remind your patient, who will be awake throughout the procedure, that he must stay perfectly still – even the slightest twitch could cost him his life.



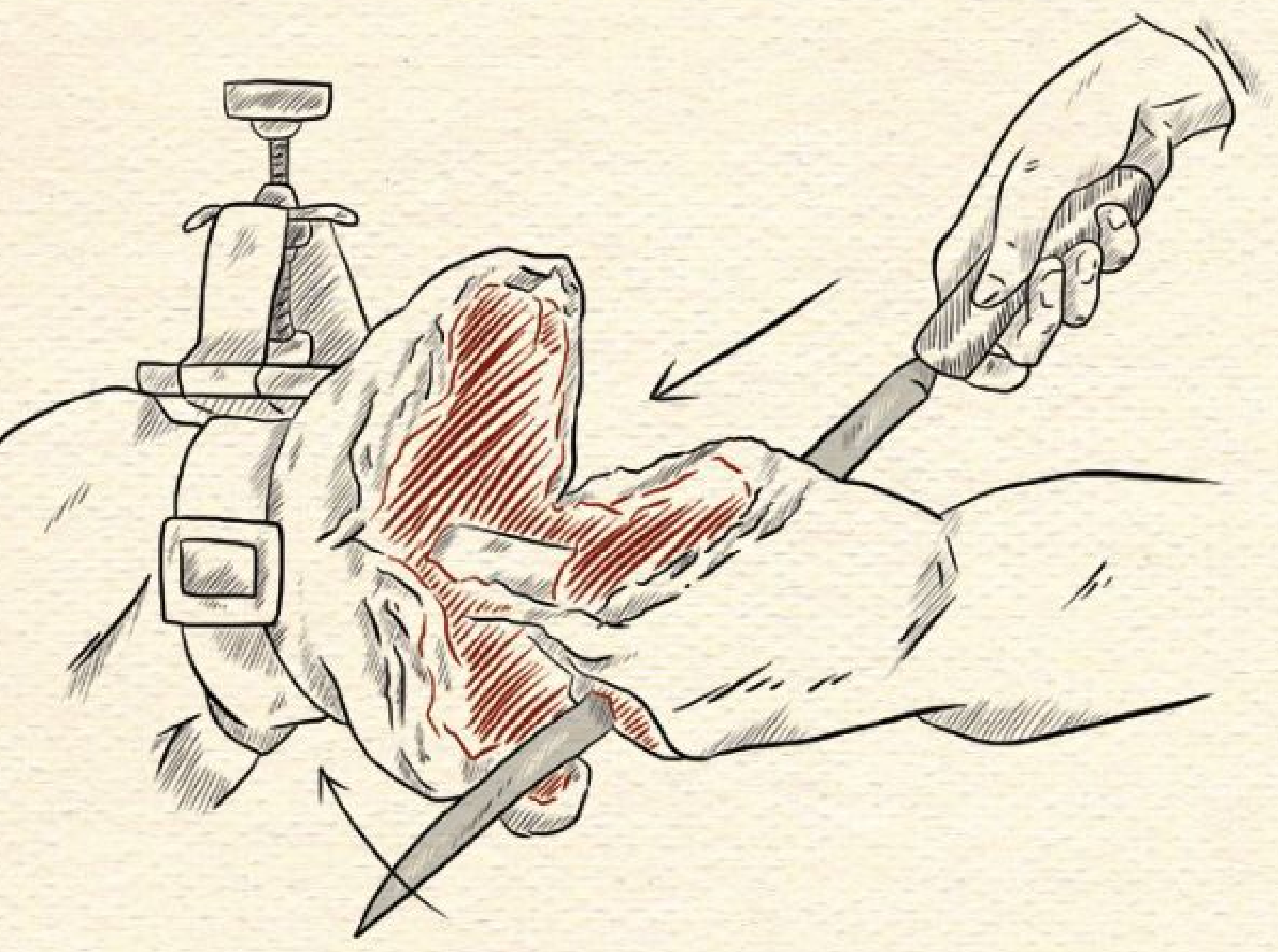
Step 02. Tighten the tourniquet

Wrap the canvas strap around the patient's limb and turn the screw clockwise to tighten the brass plates. This will constrict the blood flow.



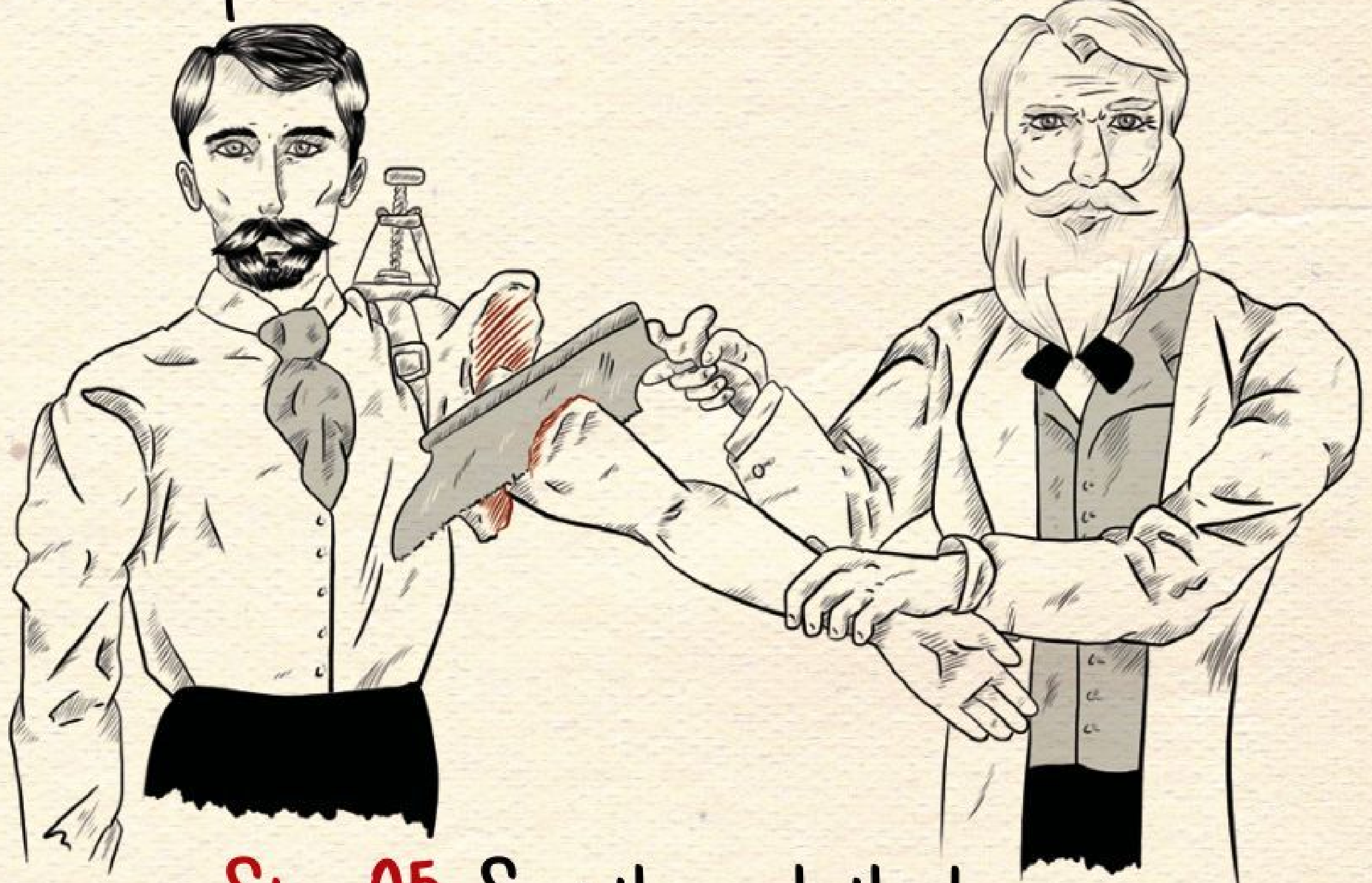
Step 03. Slice the flesh

Take the knife with the curved metal blade and make your first incision in a circular motion, slicing through all the flesh and muscle around the bone.



Step 04. Repeat

Repeat on the other side. This is called the 'tour de maitre', or the turn of the master, and should be performed as quickly as possible.



Step 05. Saw through the bone

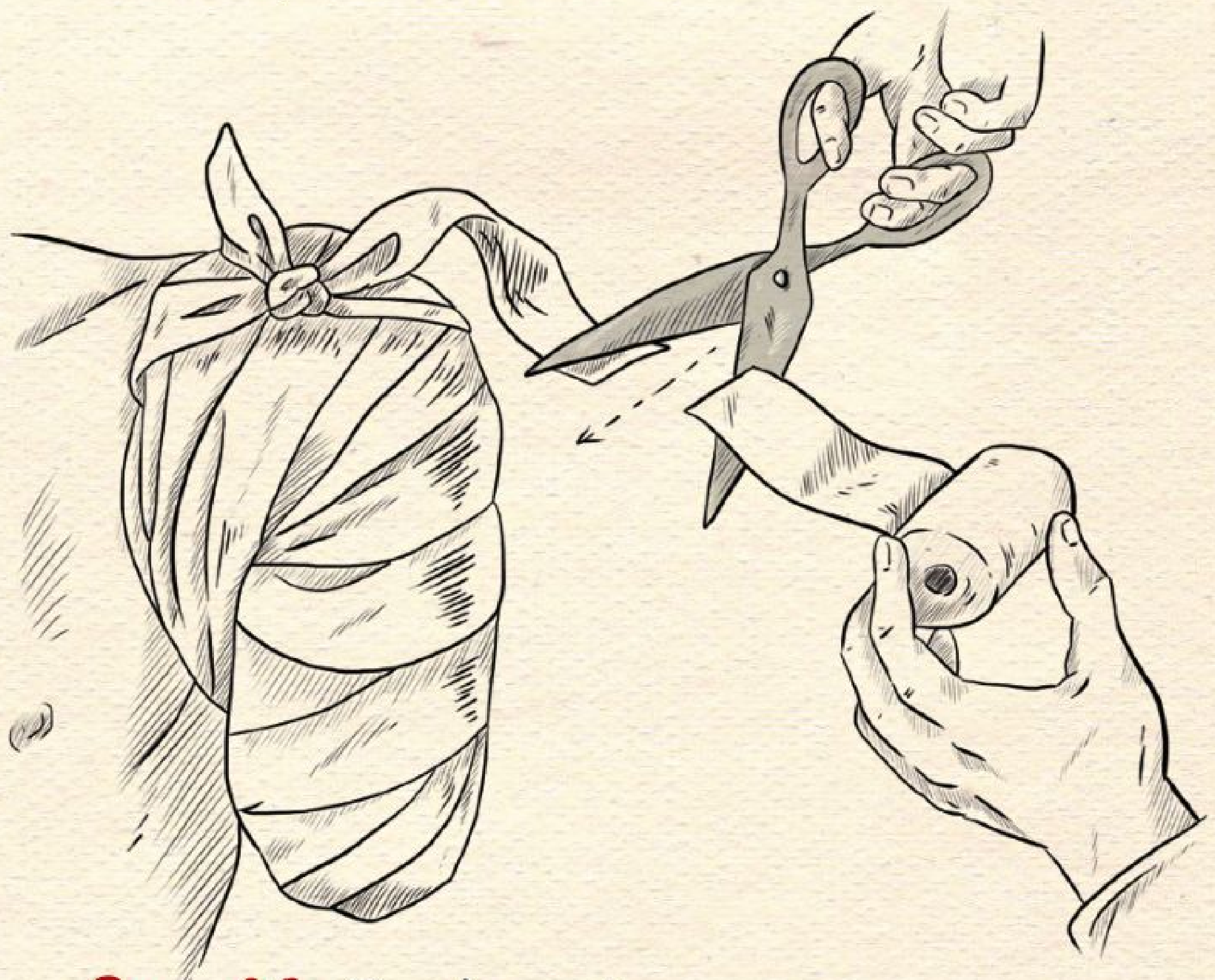
With the amputation saw, cut back and forth through the bone until the limb is free. Drop it into a bucket filled with sawdust.

Step 06. Stich up

Tie the main artery with a reef knot and repeat on the smaller blood vessels. When the blood has stopped flowing, stitch up the wound.

Step 07. Wrap in bandage

Bandage the stump using circular turns. If not done correctly, you may risk choking the stump and slowing down the healing process.



Step 08. Final touches

Listen to the rapturous applause from the students watching in the wings. Wipe down the table with a rag ready for your next patient.

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RAPID RELIEF BY RAIL

The ambulance trains of World War I saved countless lives and lessened the suffering of soldiers wounded in battle

It was the bloodiest day in the history of the British Army. On 1 July 1916 the Battle of the Somme commenced. Before the sun set, 57,470 soldiers became casualties, and 19,240 of them were dead.

During that horrific day and the three that followed, ambulance trains completed 63 treacherous round trips from stations where wounded men lay awaiting evacuation to port cities on the coast of France. The trains brought 33,392 casualties from the combat zone. The immense carnage at the Somme required the trains to carry wounded well beyond their designated capacity. For example, Train No. 29 transported 761 men while fighting raged on 2 July – more than twice its allotted load.

By the time of the Battle of the Somme, it was terribly apparent to soldier and civilian, field marshal and private alike, that World War I had brought death, injury and destruction on such a scale that had previously been impossible to conceive. Without the yeoman service of the ambulance trains, staffed by tireless medical personnel of the Royal Army Medical Corps and Queen Alexandra's Imperial Medical Nursing Service – including doctors, nurses, orderlies and other personnel – the fearful harvest of death reaped in the Great War would doubtless have been substantially higher.

Although the concept of the ambulance train had been tried and proven effective in the 19th century in the Crimea, American Civil War, the Zulu and Boer Wars, it was the modern combat of the 20th century – facilitated by the machine gun, bolt-action rifle, heavy-calibre artillery and dreaded poison gas – that brought its lifesaving capabilities further to the attention of both the military and the public.

Throughout the war of 1914-18, Britain, France and Germany operated ambulance trains, often painted white with the Red Cross emblazoned on their cars for easy recognition, and their contribution was very apparent from early in the conflict. In the month of December 1914 alone, more than 100,000 British casualties were evacuated aboard trains from battlefields in Flanders.

The dark clouds of conflict had gathered for some time prior to the outbreak of the war, and two years before the first weapon was fired, the British government, anticipating tremendous numbers of wounded, authorised

> "In the month of December 1914 alone, more than 100,000 British casualties were evacuated aboard trains from battlefields in Flanders"

A group of nurses in front of an ambulance train, before being sent to France in 1917. There were 51 ambulance trains in service, run by dedicated doctors, nurses and orderlies

This sketch depicts the nocturnal unloading of an ambulance train at a rail siding in the town of Étaples-sur-Mer, France

the formation of the Railway Executive Committee with responsibilities for the wartime operation of the nation's railways. Within the scope of the committee's charge came the efficient transportation of the wounded that arrived in Britain from battlefields on the European continent. To that end, plans were produced for a dozen hospital trains to operate exclusively in Britain. By the end of 1914, however, when the French were unable to provide adequate locomotives and rolling stock for both the British and French armies, the role of the Railway Executive Committee expanded to provide ambulance trains for use on the continent as well.

Days after Britain entered the war, three locomotives and numerous rail cars were presented to the Royal Army Medical Corps. These were refitted with surgical dressing rooms, patient wards and dispensaries, and were designated British Ambulance Trains 1, 2, and 3. Meanwhile, skilled railway workers were dedicated to the production of ambulance trains, the first of which arrived at Southampton just 20 days after Britain entered the war in August 1914. Built by companies such as the London and South Western Railway, Lancashire and Yorkshire Railway, and Great Western and Eastern Railways, 20 ambulance trains were operating in Britain and 31 in France by the end of the war. As early as 1915, 12 trains had been shipped to the continent and entered service, the most recent of them becoming the first train equipped with purpose-built operating suites to allow surgery to be performed.

As the country mobilised, members of the United Kingdom Flour Millers' Association presented two ambulance trains to the Red Cross. Working cooperatively with a French train, the trio carried 461,844 wounded men from 1915 to the end of the war. Donations and private funds regularly supported the effort to build more ambulance trains. Dolls dressed in nursing uniforms were sold on station platforms to solicit funds.

The ambulance trains themselves were marvels of ingenuity and the utilisation of available space. A typical train consisted of the locomotive and 15 to 20 carriages, including a dispensary car, two kitchens, a personnel car and a brake and storage van, or caboose. As casualties mounted and the demand for ambulance trains increased during the course of the war, designs were modified and improved. The trains might stretch half a kilometre (0.3 miles) along the track. A medical officer, usually with the rank of major, was in charge of the activities of two additional doctors - usually lieutenants - three or four nurses and a complement of 40 orderlies, who cared for a large number of wounded aboard a single train. Designed to carry 400 patients, it was not uncommon for more than 500 to be loaded aboard.

The patient cars were outfitted with berths anchored to the walls on two or three levels, accommodating up to 36 patients each. Some trains were equipped with berths that could be raised and lowered, allowing patients who were slightly wounded and able to sit up to enjoy conversation, a cigarette and even a cup of freshly brewed tea. It was the first taste of home that many of the men, scarred physically and emotionally by their experiences in the trenches, would savour. Trains placed in service later in the conflict were equipped with fans to disperse lethal, lingering gas that had been used indiscriminately in chemical warfare attacks.

Casualties were generally moved through stages of evacuation from the front. Regimental aid posts were located 180-275 metres (200-300 yards) from the lines. Stretcher cases and walking wounded received basic care and were then moved to an advanced dressing station another 365 metres (400 yards) to the rear, or another kilometre and a half (one mile) back to a main dressing station, where lifesaving emergency surgery could be performed on a limited basis. From there, patients were carried by truck or horse-drawn wagon to a field ambulance complex, which included more than 200 personnel, operating tents, ward tents and

A trio of nurses stand in the operating theatre of an ambulance train rail car during World War I

"The stench of burned or decaying flesh and other odours was at times overwhelming" other necessary facilities. Men were triaged and information on their condition was recorded. The next leg of the evacuation journey took wounded men to the casualty clearing station, several kilometres further to the rear. These expansive facilities covered almost a kilometre of ground, treating as many as 1,000 wounded at a time and providing the most comprehensive medical care available in such close proximity to the fighting.

Ambulance trains operating in France transported the wounded from casualty clearing stations near railheads to base hospitals at such port cities as Rouen, Calais and Boulogne – the busiest location on the coast, where thousands of casualties were taken for the eventual cross-channel voyage to Britain. Experienced orderlies in Boulogne became so proficient at clearing the casualties that they once unloaded 123 patients from a train in only 19 minutes.

Ambulance trains followed established rail lines from the front to the English Channel ports, and the village of Étaples-sur-Mer in the Pas-de-Calais was a beehive of activity. One of the largest Allied hospital complexes in Europe was established there overlooking the picturesque Canche estuary. Even its 20,000-bed capacity was strained, receiving 40,000 sick and wounded in a single month in 1917, delivered by a dozen ambulance trains. Today, the town is the site of an expansive cemetery where 11,500 soldiers of the British Commonwealth are buried.

Although swift evacuation was a hallmark of the railway lifeline, travel was very difficult at times, and at least one of the journeys from Braisnes in northern France to Rouen required an arduous three days. For some injured soldiers, boarding the train came as a blessed relief. For others rail travel was an ordeal in itself. While they were at least in a safer environment and receiving available medical care, the ride was often rough, jostling men with painful wounds or broken bones and adding to their misery. "I remember the journey as a nightmare," one former casualty reflected. "My back was sagging, and I could not raise my knees to relieve the cramp, the bunk above me only a few inches away."

Time was precious, and men continually boarded the trains in soiled uniforms caked with mud, their wounds crudely bandaged and oozing blood. The stench of burned or decaying flesh and other odours was at times overwhelming for many. Maintaining reasonably sanitary conditions was a constant battle. "They come straight from the trenches," one nurse recalled, "and are awfully happy on the train with the first attempts at comforts they have known. One told me they were just getting their tea one day, relieving the trenches when 'one o' them coal-boxes' sent a 256-lb shell into them, which killed seven and wounded fifteen. One shell! He said he had to help pick them up and it made him sick."

Service aboard an ambulance train on the continent was particularly hazardous. Routinely, the trains approached within 16 kilometres (ten miles) of the front lines to reach casualty clearing stations. When they were in close proximity to ammunition dumps, supply depots or troop concentrations, they often came under fire from enemy artillery and strafing aircraft. One nurse recalled that the concussion of bombs and shells blasted every window out of the 16-car train on which she was serving. An orderly serving in Britain remembered that his train regularly pulled into railway tunnels, taking shelter against the bombs dropped by German Zeppelins. A jagged shard of shrapnel once crashed through his onboard office.

> "It was the first taste of home that many of the men, scarred physically and emotionally by their experiences in the trenches, would savour"

Early trains did not provide easy access between rail cars, and nurses caring for patients in multiple carriages were obliged to move outside and step over to the adjacent car. It was a hazardous undertaking, particularly while carrying an armload of medicine and supplies. At night a lantern was necessary, compounding the difficulty.

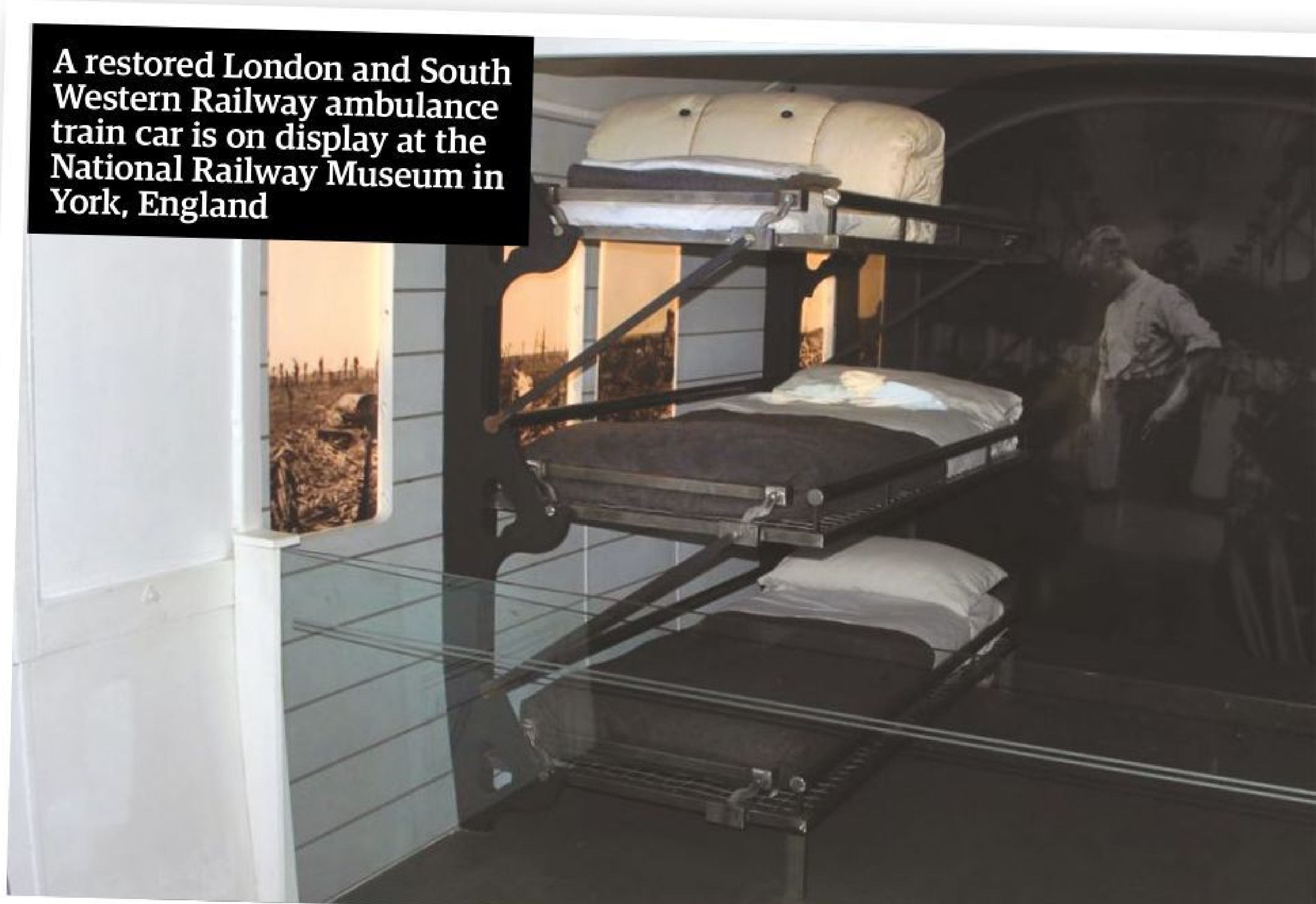
Ambulance train personnel were often stretched beyond the limits of endurance, working around the clock, on their feet for 24 hours at a time as doctors assessed casualties, nurses dressed wounds and comforted patients and orderlies retrieved water and bandages and cleaned continually. While many of the patients were stabilised before they were placed aboard a train, deaths were inevitable, and the strain of wartime service took its toll on the caregivers. In a letter home, nurse Kate Evelyn Luard wrote of her experience in France: "Imagine a hospital as big as King's College Hospital all packed into a train… No one person can realise the difficulties except those who try to work on it."

Some medical personnel lived aboard the same ambulance train for many months, forming lasting personal and professional relationships. They treasured the moments of rest and visited one another in the mess rooms that were part of their living quarters. Personal touches were added to make spaces more comfortable, and the trains themselves were equipped with showers and steam heating – veritable luxuries when just outside the window temperatures were freezing and other people had not bathed for lengthy periods.

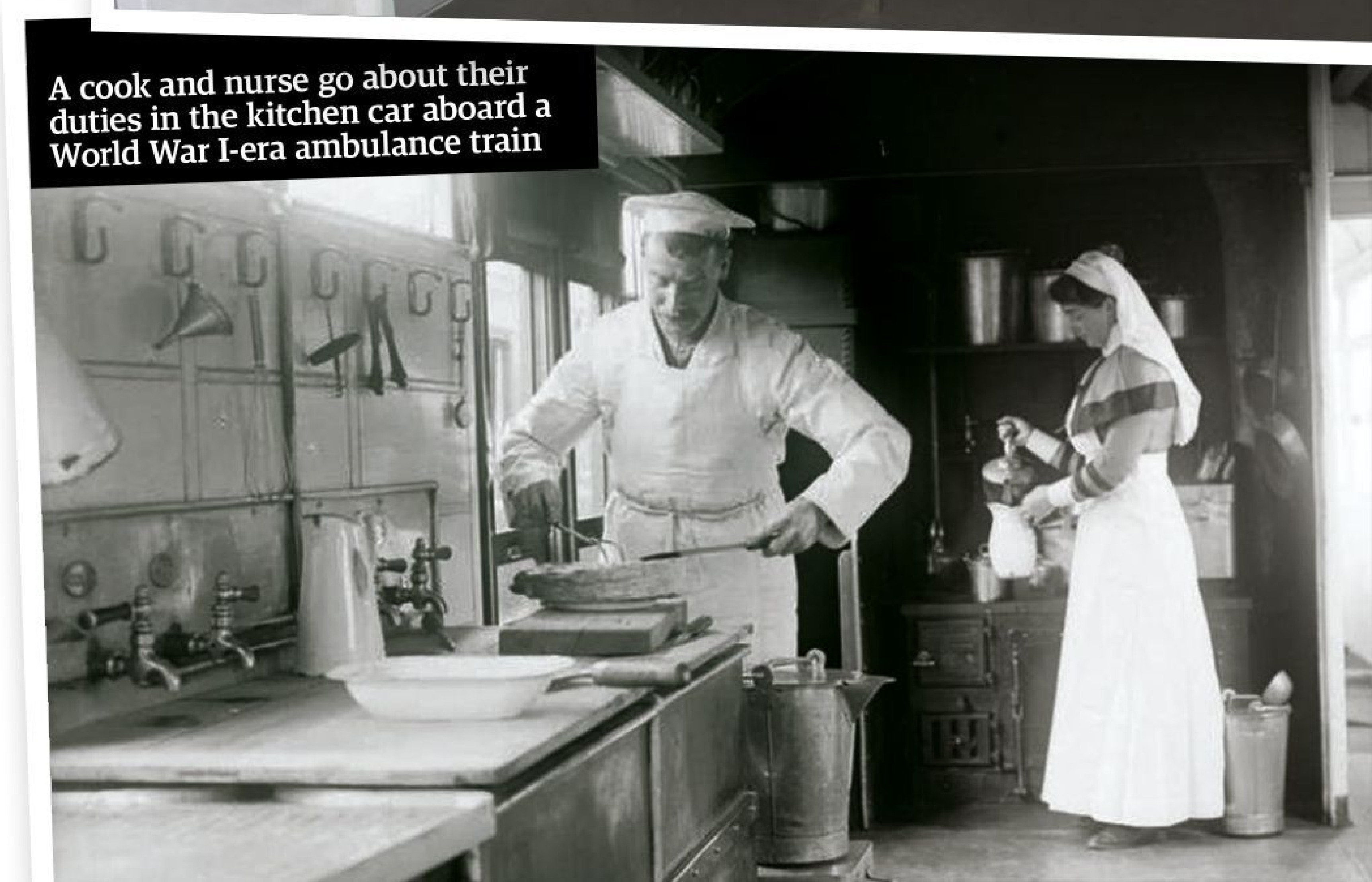
Many wounded British soldiers were repatriated through the large port cities of Dover and Southampton. During the course of the war, Dover received 1,260,506 casualties, the equivalent of 7,781 fully loaded ambulance trains. After arriving in Britain, the wounded were loaded aboard domestic ambulance trains and taken to hospitals across the country. Railway stations became focal points of the war years for Britons, who said farewell to their sons there as they went off to war and then ventured down to greet many of them again as they came home grievously injured.

One observer told a local newspaper reporter, "The unloading of an ambulance train is always a sad sight. They crawl along, moving very slowly. They are bowed and listless… These men left England fine, alert, young soldiers."

Such is the tragic circumstance of war. In the midst of carnage, though, the ambulance train became an essential component of the British medical care continuum during World War I. By the time the conflict came to a close, 2.7 million wounded soldiers had travelled aboard the ambulance trains. The system's success was such that system was again employed in World War II and during later conflicts of the 20th century.



A restored London and South Western Railway ambulance train car is on display at the National Railway Museum in York, England



A cook and nurse go about their duties in the kitchen car aboard a World War I-era ambulance train

BATTLEFIELD MEDICINE

Advances in medical treatment protocols and theatre facilities have enabled medical personnel to save more lives during conflict

Since the earliest days of battlefield medicine, nursing professionals have utilised the latest available treatments and techniques to render the best possible care to critically wounded patients. The evolution of such care has resulted in greater survivability as these nurses demonstrate their capabilities under conditions that remain difficult at best. QARANC nurses complete rigorous training to fulfil their collective mission.

Soldiers carry a wounded comrade through the mud in 1917 to the medical professionals behind the front line

> “The evolution of such care has resulted in greater survivability”

BATTLEFIELD LIFESAVING

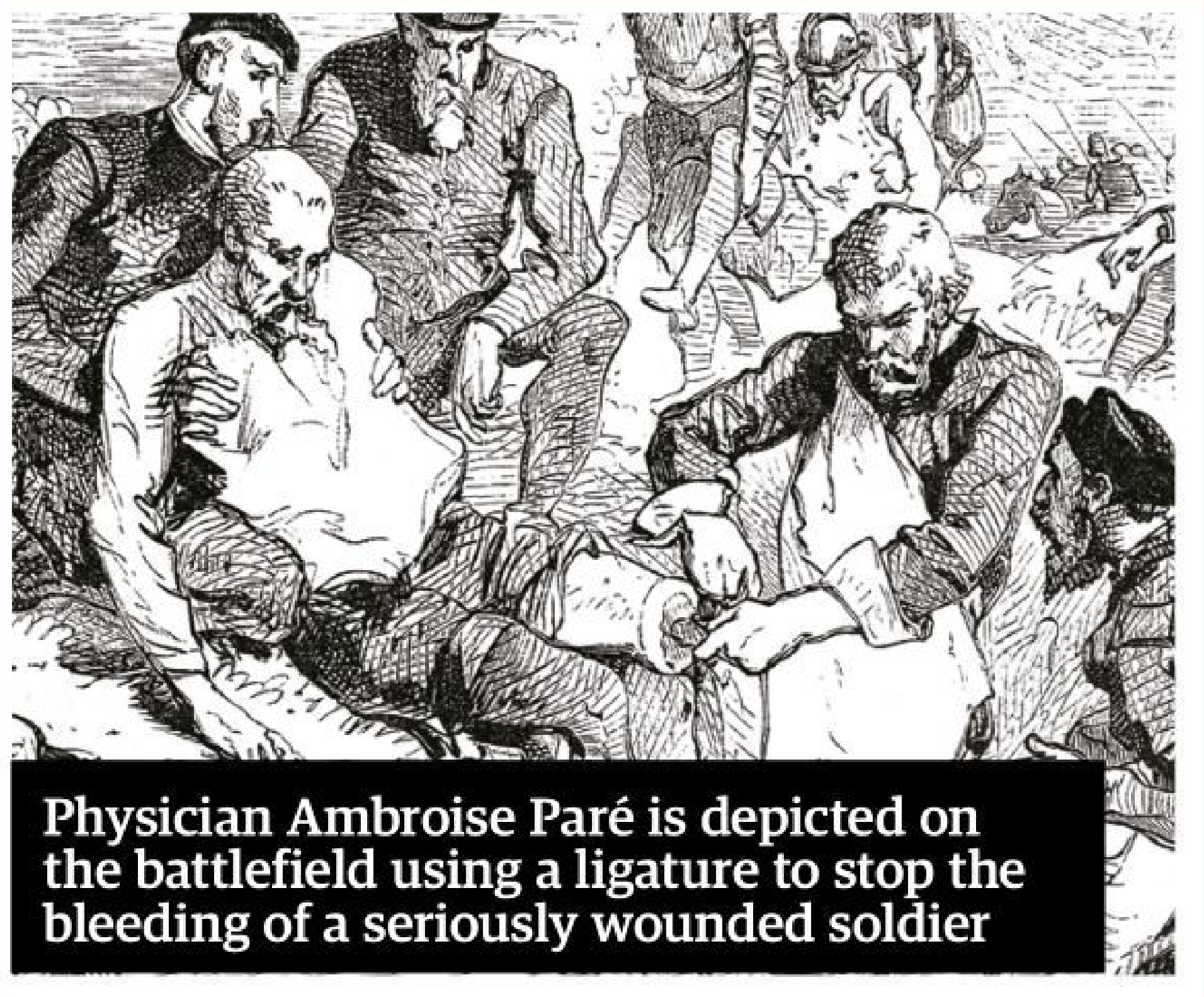
Throughout the history of warfare soldiers often died of their wounds on the battlefield. For want of a simple tourniquet they bled to death, and traumatic amputation resulted in shock. There was little understanding among fellow soldiers who might attempt to render aid. But through the introduction of medical personnel trained to perform life-saving treatments amid the rigours of combat, along with the development of battlefield medicine, the likelihood of a soldier dying on the battlefield due to an untreated wound has diminished significantly.

Greater understanding of infection control, the realisation that severed arteries must be closed to prevent a casualty from ‘bleeding out’, antibiotics, readily available blood plasma, sustaining fluids delivered on or near the battlefield, rapid ground or aerial evacuation and the presence of trained medical personnel in field hospitals are just a few of the enterprising developments that frequently save soldiers’ lives. Some of these have been learned through trial and error, while others have been adapted to combat conditions with advances in medical science.

Medicine bottles from 1914, which were used to treat a variety of conditions. Advances in medicine helped reduce the number of deaths from illness

CLOSING THE WOUND

In the late 16th century French physician Ambroise Paré pioneered techniques in battlefield medicine, such as rapidly closing the arteries that bled profusely as the result of a traumatic amputation to prevent the casualty from dying due to loss of blood.



Physician Ambroise Paré is depicted on the battlefield using a ligature to stop the bleeding of a seriously wounded soldier

This portable German WWI anaesthetic kit consists of a chloroform bottle, chloroform dropping bottle and Schimmelbusch mask in a bag

ANAESTHETIC

During the Crimean War, Russian physician Nikolay Pirogov was the first to use ether, an anaesthetic, on the battlefield, reducing the pain of the casualty and contributing to ease of treatment and stabilisation. Pirogov had been the first to use anaesthetic in a surgical setting in 1847, shortly before the war.

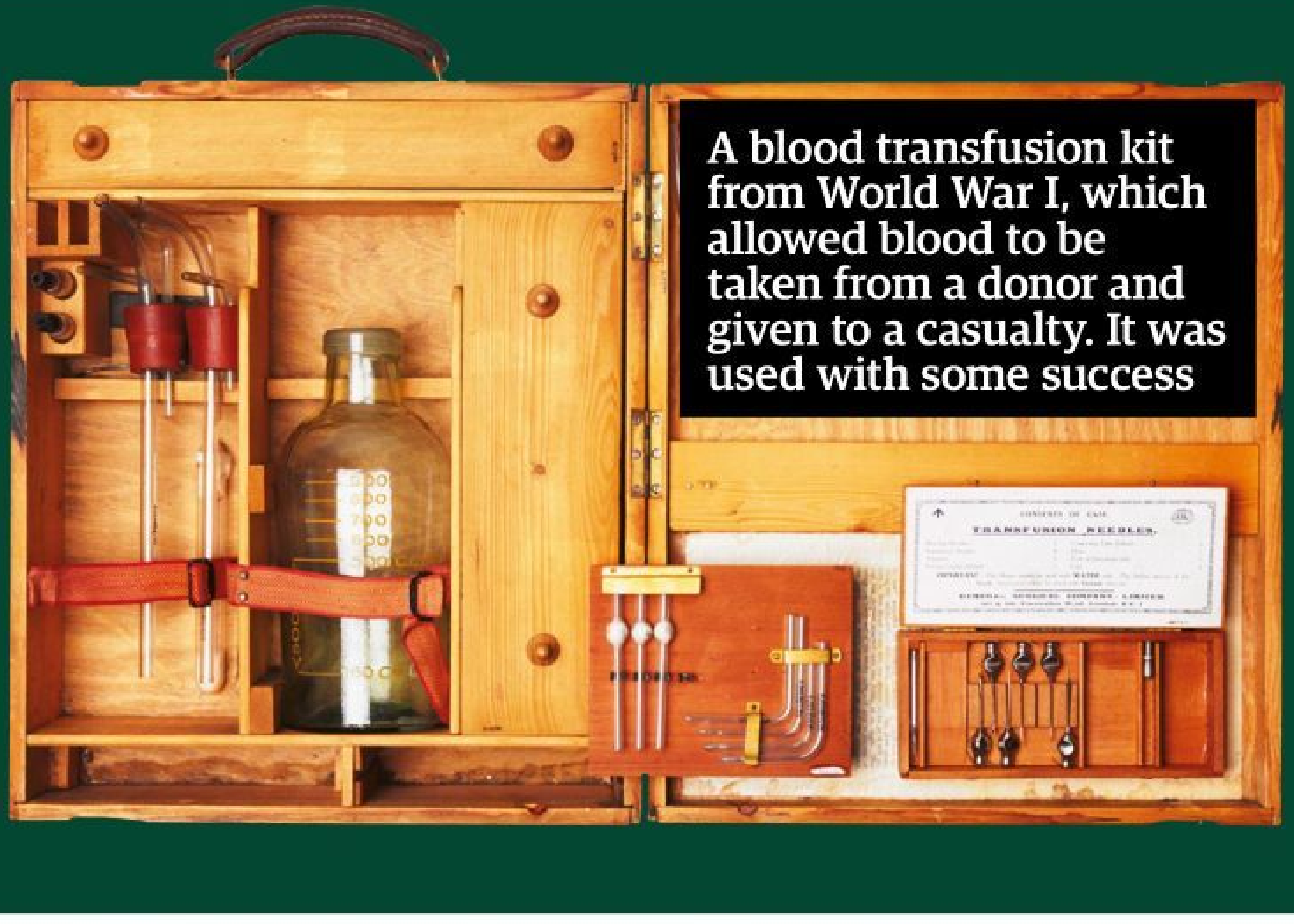
REMOTE PHYSIOLOGICAL MONITORING

A rather recent development, remote physiological monitoring relays information about casualties, such as vital signs and other data prior, to and during MEDEVAC operations, alerting medical personnel on the condition of incoming wounded. With real-time information on a patient's condition, doctors and nurses are better prepared to deliver appropriate trauma treatment.

Instruments such as this wristwatch capable of transmitting data are revolutionising battlefield medicine with a new standard of care

BLOOD TRANSPORTATION

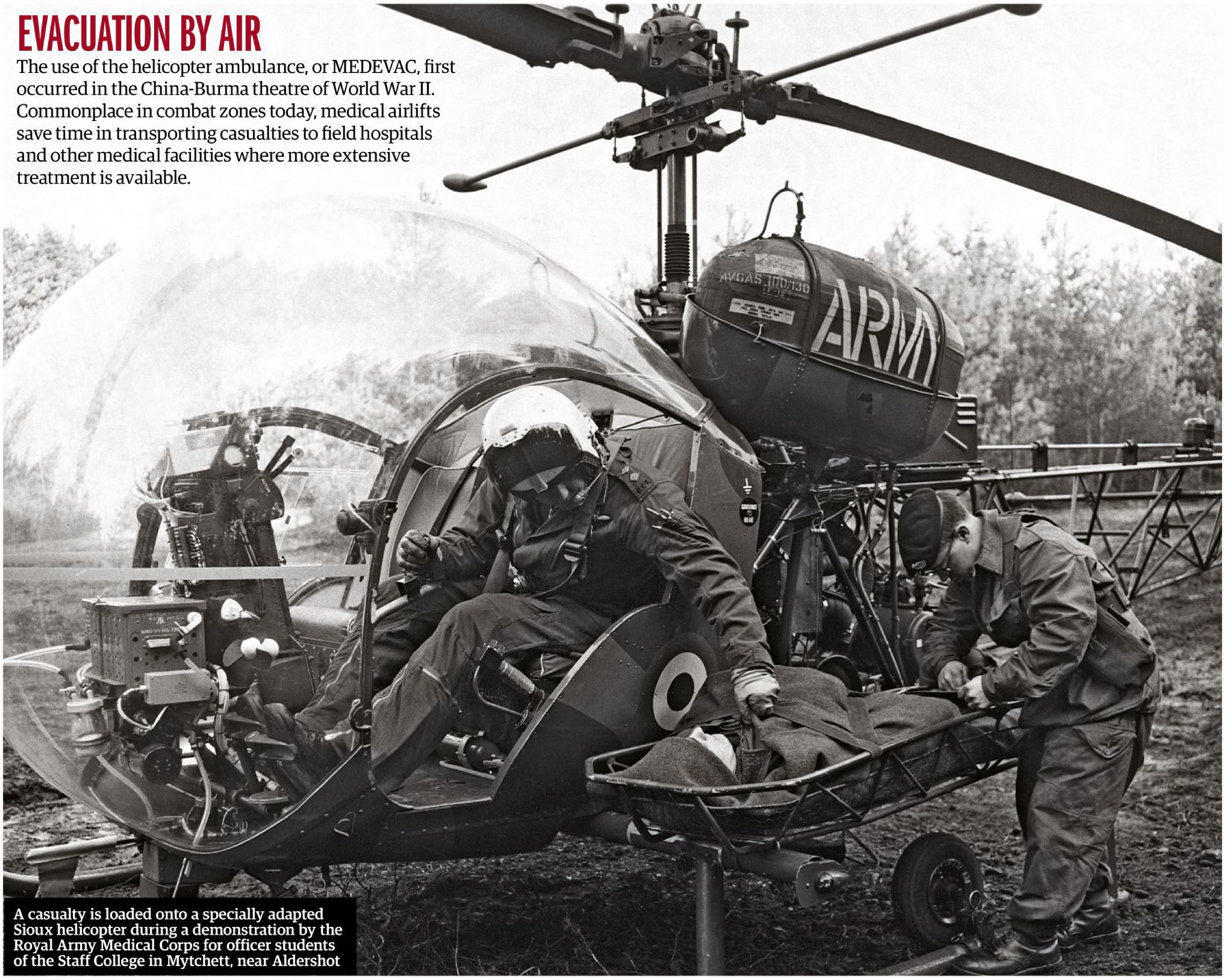
The transportation of blood in glass tubes, delivered by refrigerator truck, was first introduced during the Spanish Civil War. Transfusions were made possible much more quickly, saving precious time in treatment, along with another innovation of the period, the mobile operating room.



A blood transfusion kit from World War I, which allowed blood to be taken from a donor and given to a casualty. It was used with some success

EVACUATION BY AIR

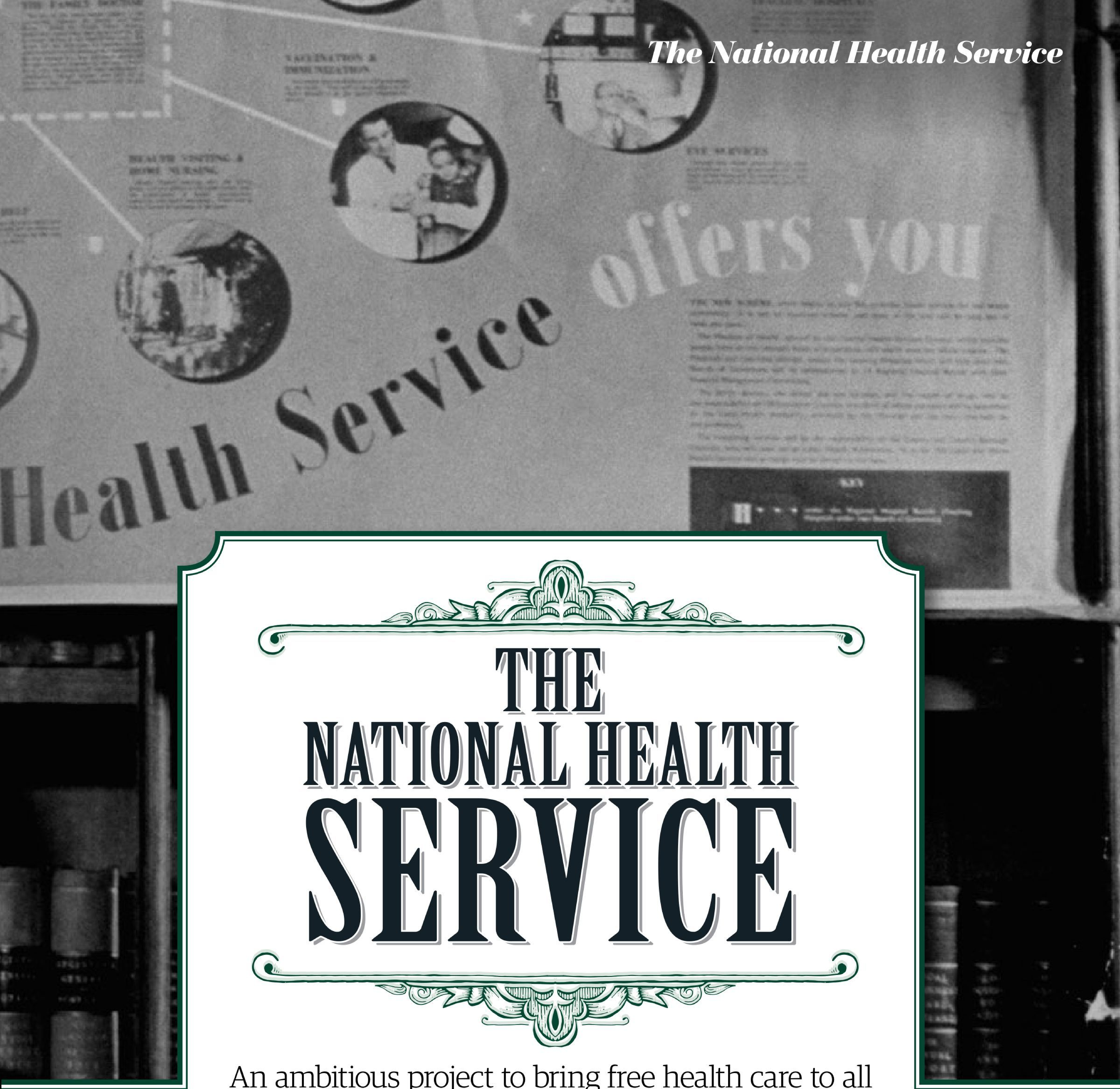
The use of the helicopter ambulance, or MEDEVAC, first occurred in the China-Burma theatre of World War II. Commonplace in combat zones today, medical airlifts save time in transporting casualties to field hospitals and other medical facilities where more extensive treatment is available.



A casualty is loaded onto a specially adapted Sioux helicopter during a demonstration by the Royal Army Medical Corps for officer students of the Staff College in Mytchett, near Aldershot

© Alamy, Getty Images

Aneurin Bevan was a driving force behind the establishment of the NHS


THE FAMILY DOCTOR
VACCINATION & IMMUNISATION
HEALTH VISITING & HOME NURSING
EYE SERVICES
Health Service offers you
KEY

THE NATIONAL HEALTH SERVICE

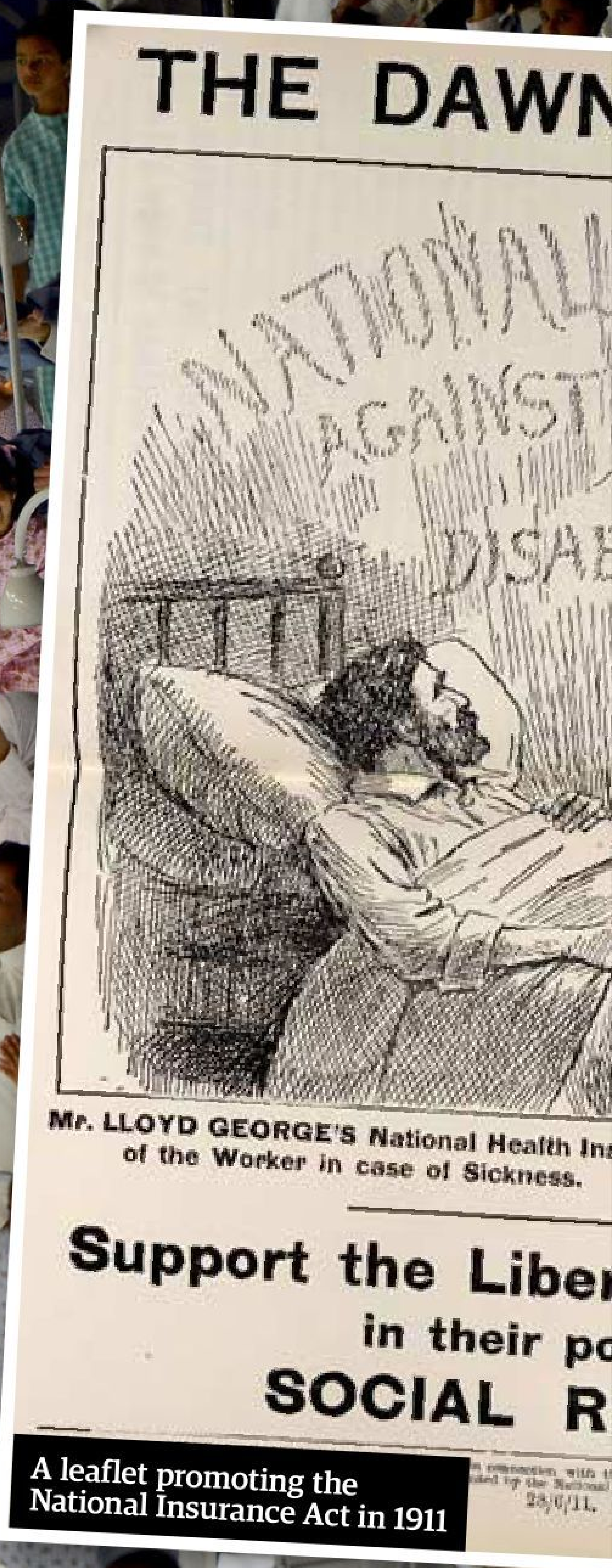
An ambitious project to bring free health care to all

In 1911, Benjamin Moore knew that something had to change. In *The Dawn of the Health Age*, he put forward his idea for a national medical service - private doctors, charitable hospitals and the Poor Law just were not working for the general populace. Maladies that were preventable weren't being prevented, and Moore argued that this was because there wasn't a unified health service. However, as logical as it may have seemed, Moore's publication wasn't without stiff opposition. According to one reviewer, Moore's criticisms into the working conditions of doctors are moot as "great progress has already been made in this country in the prevention of disease."

Towards the end of that year, the National Insurance Act 1911 came into being. While helping to tackle unemployment, it also provided a scheme whereby workers could take sick leave and also gain access to free treatment for tuberculosis. It was a step in the right direction, but many were angry that the Act was compulsory, their obligatory contributions now reducing their already slim wages. Moreover, only workers were covered, not their families, and for the self-employed and unemployed, nothing had changed.

1920 saw further progress, though. Lord Dawson, who had been commissioned by the Ministry of Health, conducted a report in which he indicated the structure that a national health service might take. This was followed by proposals from several organisations in the 1930s, but there wasn't much cohesion in practice. While the Nuffield Provincial Hospitals Trust brought in some regionalisation, the dean of the London School of Hygiene & Tropical Medicine organised a weekly group of doctors from different fields. The group became known as the Gas Bag Committee, and recognised that only the state could give them the large amounts of money

The NHS has become such a strong part of British life that it featured in the opening ceremony of the 2012 Olympic Games in London



THE DAWN

NATIONAL
AGAINST
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Mr. LLOYD GEORGE'S National Health In
of the Worker in case of Sickness.

Support the Liber
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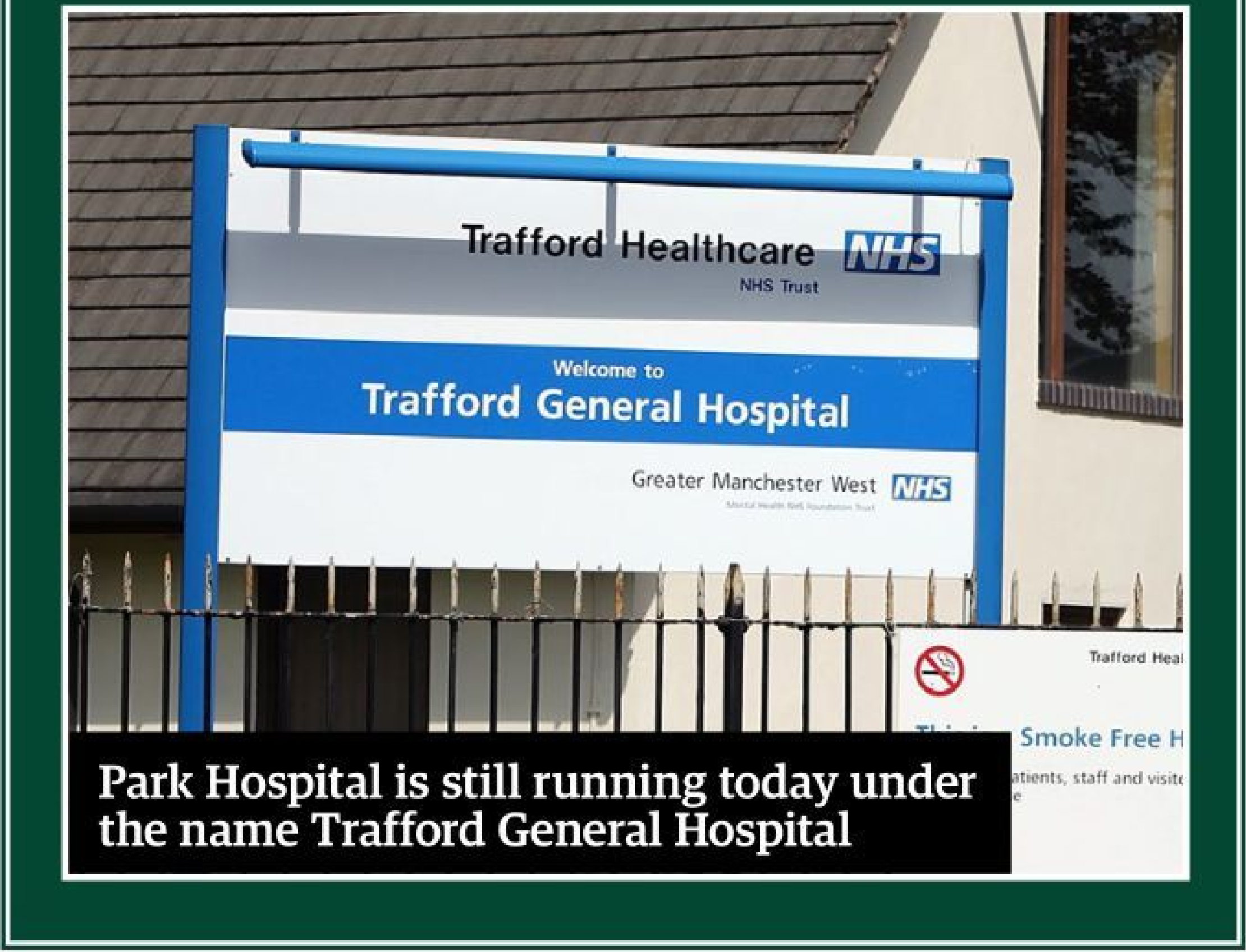
A leaflet promoting the National Insurance Act in 1911

PARK HOSPITAL

Known today as Trafford General Hospital, Park Hospital's opening marked the official beginning of the NHS. Opened by the then health secretary Aneurin Bevan, it was the coming together of years of planning and fighting. But before its grand opening under the NHS, the hospital had been in use for almost 20 years.

Originally opened on 17 December 1928 by Princess Mary, daughter of King George V, ownership of the institution passed to Lancashire County Council in 1929 after the removal of the poor law unions. 1939 then saw it be taken over by the War Department, and it began to treat military personnel from the Allied nations. It even played host to Glenn Miller and his US Army Air Force Band, and world champion American boxer Joe Louis.

In 1948, Bevan symbolically received the keys to the hospital from Lancashire County Council – after all, it was now part of a national institution, no longer belonging to the county. Nurses formed a guard of honour outside, and Sylvia Beckingham became the NHS's first ever patient. Park Hospital was also the birthplace of the first baby to be born under the NHS, Sandra Pook.



Park Hospital is still running today under the name Trafford General Hospital

they needed for teaching hospitals – but then how would they stay independent?

It was during World War II that things started to come together. With the enemy bombing the cities, many needed medical assistance, and so free hospital treatment was offered for the wounded, including civilians who had been caught up in the Blitz. On top of that, the hospital services were reorganised into geographical groups. It was the war that brought everything together under an emergency medical service – and it proved that something could be done to improve the country's health service once and for all.

In 1942, the Beveridge Report was released, which focused on social welfare systems. William Beveridge was an economist and social reformer but his report spoke little of how what he saw as an essential national health service could be funded – a factor that would cause problems later down the line. But after the report's release, the ruling Conservative Party created a white paper in which they discussed a future health service led by local authorities.

Immediately after the war, the Conservatives were out, and Labour was in with a landslide victory. How? Alongside its campaign slogan of 'Let us face the future', it promised to deliver a tax-funded, universal National Health Service (NHS).

> The NHS was born out of the idea that good health care should be available to everyone, regardless of their wealth

After the victory, Aneurin Bevan, the new minister for health, got started right away.

Bevan's plan was to revolutionise health care by bringing everything under one umbrella and making it free at point of use, as opposed to the insurance-based schemes that were in operation, much like they are in the United States today. The funding for the NHS would come from taxation, meaning that the rich would contribute more than the poor who couldn't afford it, and treatment could be given at any institution in the country – even to foreigners living in Britain temporarily.

A three-tier structure was soon developed with the minister of health sitting at the top, presiding over everything, and the different parts of the organisation were designed to interact with each other. First there were the hospitals, which were nationalised and then organised by region. Then, grouped together were the general practitioners, dentists, opticians and pharmacists. Finally, the local authority health services like community clinics, which were controlled by medical health officers.

But as good as it all sounded, there was fierce opposition from politicians across the board and even members of the medical profession. One of the main concerns was money – doctors made the most of their living from private patients and didn't necessarily trust that the government would pay them a fair wage. The government was forced to make a number of compromises to bring them on board, although Bevan wasn't happy about it.

No one predicted the demand for the NHS in its first year. After the first hospital opened in Manchester on 5 July 1948, the number of patients on doctors' registers rapidly rose to a staggering 30 million – the poor now had access to health care they didn't have before and they were making the most of it. While the budget for NHS opticians alone had been £1 million in that first year, the final bill was £32 million – a number that included 5.25 million glasses prescriptions. By 1951, there were 19 million glasses prescriptions a year. The financial problems weren't necessarily planned for, and in 1951, Bevan resigned when the cabinet voted to start charging for dental care and opticians services.

When the Conservatives came back into power in October 1951, the idea of taking away the NHS's funding that came from taxation came to the fore. The argument was that scientific advancements were making the system too expensive to be run – after all, the Tories had opposed the creation of the NHS in the first place. A committee led by Claude Guillebaud looked into different ways to pay for the medical care the NHS provided but, much to the surprise of the Conservatives, the NHS was found to be efficient, cost-effective and, if anything, deserving of more money. The Conservatives stopped putting up their fight – a health-care system funded by tax from everyone was well and truly part of the fabric of British life.

Since its inception, the NHS has been linked with many innovations, both technological and pharmaceutical. The service's founding coincided with the pharmaceutical industry creating new drugs, and the availability of antibiotics, anaesthetics and antihistamines were becoming much more common. Ultrasounds were being developed thanks to some war-time technologies, and in 1950, the link between smoking and cancer was realised. The first kidney transplant took place in 1954, and two years later, polio immunisation became widespread. All of these were available to all through a nationalised health system, and while the costs were piling up, public health was undoubtedly improving.

Despite all its problems, the NHS has improved the quality of life of all Britons. In 1948, the average life expectancy was 66 and 71 for men and women respectively – today, they have risen to 77.2 and 81.5. The child mortality rate has fallen, and children can receive vaccinations for diphtheria, tetanus, polio, whooping cough, influenza, MMR and meningitis C – diseases that were rife – for free.

Illness no longer bankrupts families. The dream of having a health-care service free at the point of entry for everyone became a reality despite opposition from all walks of life. By the mid-1960s, the old, out-of-date hospitals were finally replaced with new buildings, and the Porritt Committee that had criticised the three-pronged structure of hospitals, practitioners and authorities had begun to set up single authorities to take control in each region with the support of the majority of the medical profession.

The NHS is still changing today, but without it, the quality of life in the UK would be nowhere near the level we enjoy. Reforms are still pushed through parliament, like the Health and Social Care Act 2012, which strengthened the services provided. The NHS is still at the forefront of innovation, and in December 2012, a team of surgeons at Leeds General Infirmary carried out Britain's first hand transplant operation. In a world that's still evolving, the NHS has managed to remain and has kept to its core principles – being funded through general taxation, being completely free at the point of access, and bringing all branches of health care under one national organisation.

Ambulances today look very different compared to how they looked 50 years ago

The evolution of the ambulance

While ambulances had been around in some form since the 1860s, when they were horse-drawn, they weren't a part of the NHS for several years after its founding. While the NHS was in its infancy, the ambulances weren't really regulated. It was only in 1966 that the Millar report from the Ministry of Health began to suggest what equipment and levels of training were necessary. The ambulance services themselves were run by county councils. The drivers were all volunteers and the vehicles provided only the most basic services – their main aim was to get the patient to a hospital as fast as possible.

In 1974, the NHS finally took control. From then on, things began to improve with what has become known as 'out-of-hospital' care delivery. Training has become more extensive over time, and now equipment like defibrillators are used. Radio communication came into use and vehicle design was improved over time to get the ambulances we know today.

© Getty Images

In April 1948, ballot papers reveal doctors' views on joining the NHS

A ward at the first hospital to be built under the National Health Service

A nurse talks to a young patient at a London Children's Hospital c.1952

IN THE AIR

A FLYING HOSPITAL

KOREAN WAR, KOREAN PENINSULA

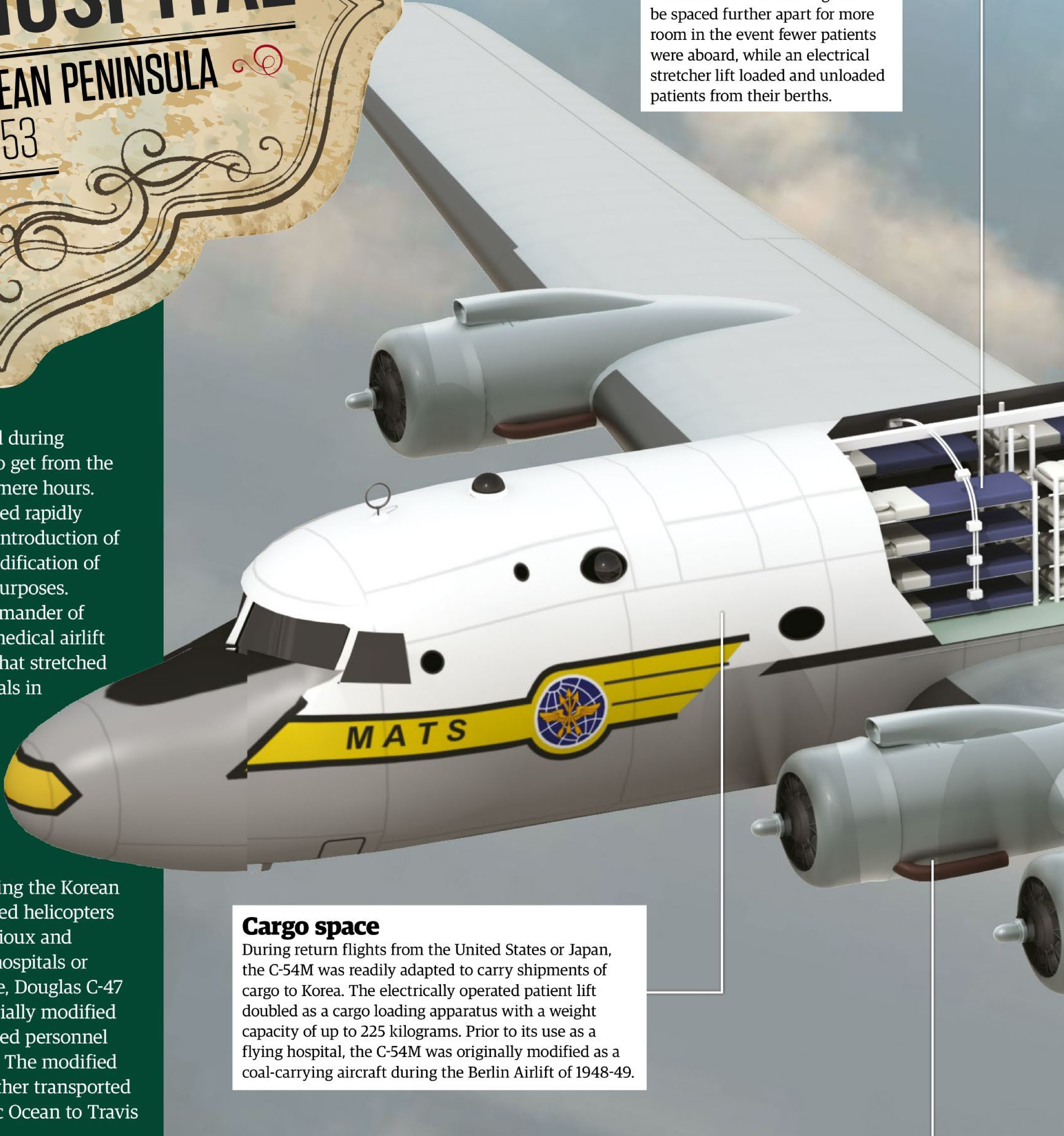
1950-53

Aeromedical evacuation saved thousands of lives during the Korean War. The doctrine was developed during World War II, reducing the time it took to get from the battlefield to care facilities from days to mere hours. US Army and Air Force procedures evolved rapidly from 1950 to 1953, particularly with the introduction of helicopters in large numbers and the modification of cargo and transport planes for medical purposes.

Major General Matthew Ridgway, commander of United Nations forces in Korea, praised medical airlift personnel involved in lifesaving efforts that stretched across thousands of kilometres to hospitals in Japan and eventually the United States. The wounded soldier in Korea had a significantly better chance of recovery, he said, "…in large measure because of his ready accessibility to major medical installations provided by rapid medical evacuation."

Typically, aeromedical evacuation during the Korean War involved rescue transport by modified helicopters or light aircraft, including the Bell H-13 Sioux and Stinson L-5 Sentinel, to mobile surgical hospitals or other facilities in the country. From there, Douglas C-47 Skytrain or C-54 Skymaster aircraft, specially modified to carry casualties, flew seriously wounded personnel to hospitals elsewhere in Korea or Japan. The modified C-54 and Boeing C-97 Stratofreighter further transported patients across the expanse of the Pacific Ocean to Travis Air Force Base, California.

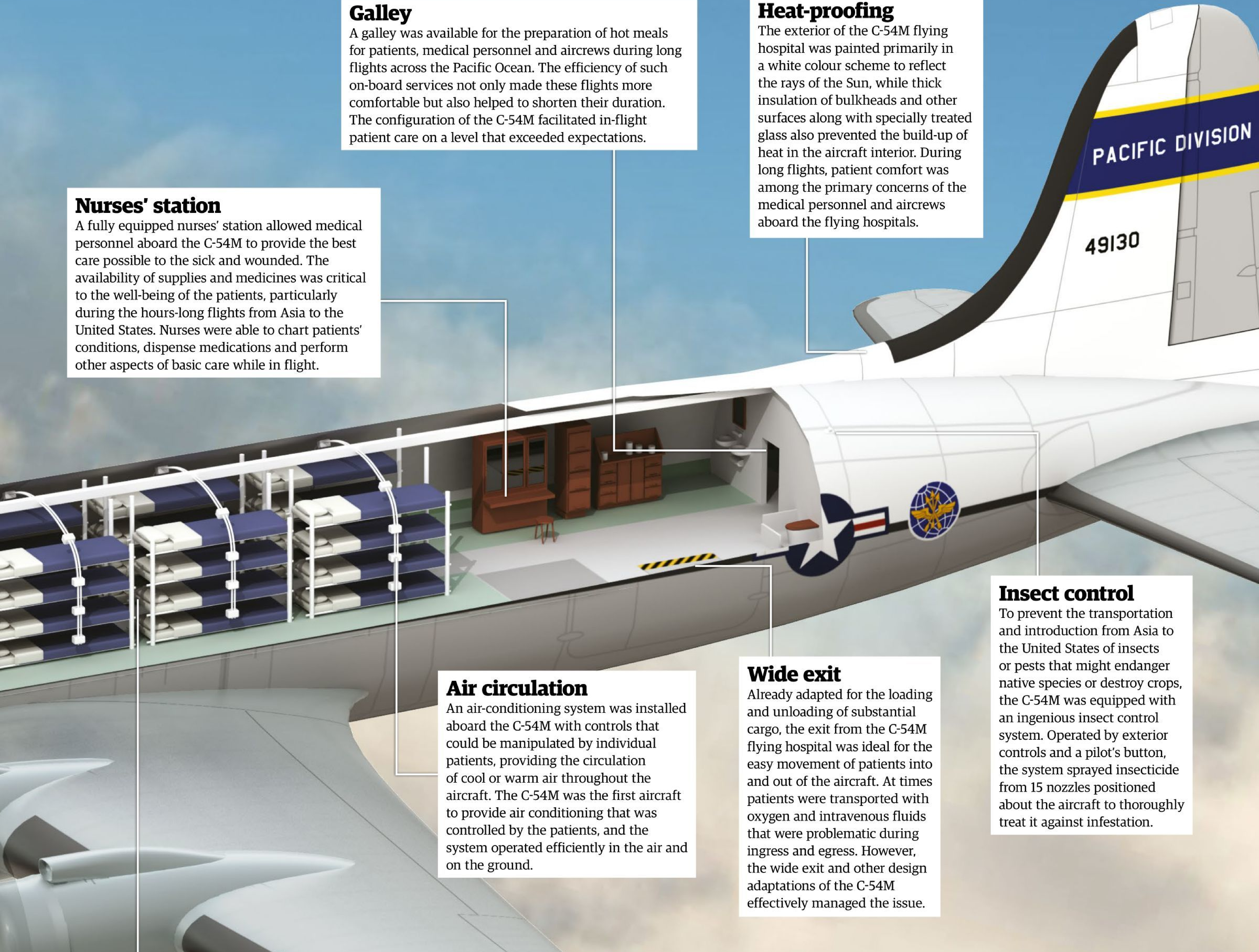
A fleet of 30 converted C-54s, designated the C-54M, entered service in the spring of 1951 and, along with the modified C-97C, actually served as flying hospitals accommodating dozens of stretchers, nurses' stations, medical supplies, and even a galley to prepare food during long flights. By the end of the Korean War, US medical evacuation troop carrier squadrons had made 12,000 flights, transporting more than 280,000 patients. More than 41,000 wounded soldiers received in-flight medical care en route from Japan to the United States.



Patient care
The C-54M flying hospital accommodated up to 32 patients in anti-vibration litter slings with 47 centimetres of clearance between each stretcher, providing a stable ride across many kilometres to medical facilities. Adjustable brackets allowed the slings to be spaced further apart for more room in the event fewer patients were aboard, while an electrical stretcher lift loaded and unloaded patients from their berths.

Cargo space
During return flights from the United States or Japan, the C-54M was readily adapted to carry shipments of cargo to Korea. The electrically operated patient lift doubled as a cargo loading apparatus with a weight capacity of up to 225 kilograms. Prior to its use as a flying hospital, the C-54M was originally modified as a coal-carrying aircraft during the Berlin Airlift of 1948-49.

Engines
The C-54M flying hospital was powered by four potent Pratt & Whitney R-2000-9 radial engines, each of which delivered 1,450 horsepower. In contrast to twin-engine aircraft, the C-54M and the C-97C were more reliable and comfortable as well as capable of completing the long-distance flights that returned casualties from Korea and Japan to medical facilities in the United States. The range of the C-54M was 6,400 kilometres, limiting necessary refuelling stops along the way.



Galley

A galley was available for the preparation of hot meals for patients, medical personnel and aircrews during long flights across the Pacific Ocean. The efficiency of such on-board services not only made these flights more comfortable but also helped to shorten their duration. The configuration of the C-54M facilitated in-flight patient care on a level that exceeded expectations.

Heat-proofing

The exterior of the C-54M flying hospital was painted primarily in a white colour scheme to reflect the rays of the Sun, while thick insulation of bulkheads and other surfaces along with specially treated glass also prevented the build-up of heat in the aircraft interior. During long flights, patient comfort was among the primary concerns of the medical personnel and aircrews aboard the flying hospitals.

Nurses' station

A fully equipped nurses' station allowed medical personnel aboard the C-54M to provide the best care possible to the sick and wounded. The availability of supplies and medicines was critical to the well-being of the patients, particularly during the hours-long flights from Asia to the United States. Nurses were able to chart patients' conditions, dispense medications and perform other aspects of basic care while in flight.

Insect control

To prevent the transportation and introduction from Asia to the United States of insects or pests that might endanger native species or destroy crops, the C-54M was equipped with an ingenious insect control system. Operated by exterior controls and a pilot's button, the system sprayed insecticide from 15 nozzles positioned about the aircraft to thoroughly treat it against infestation.

Air circulation

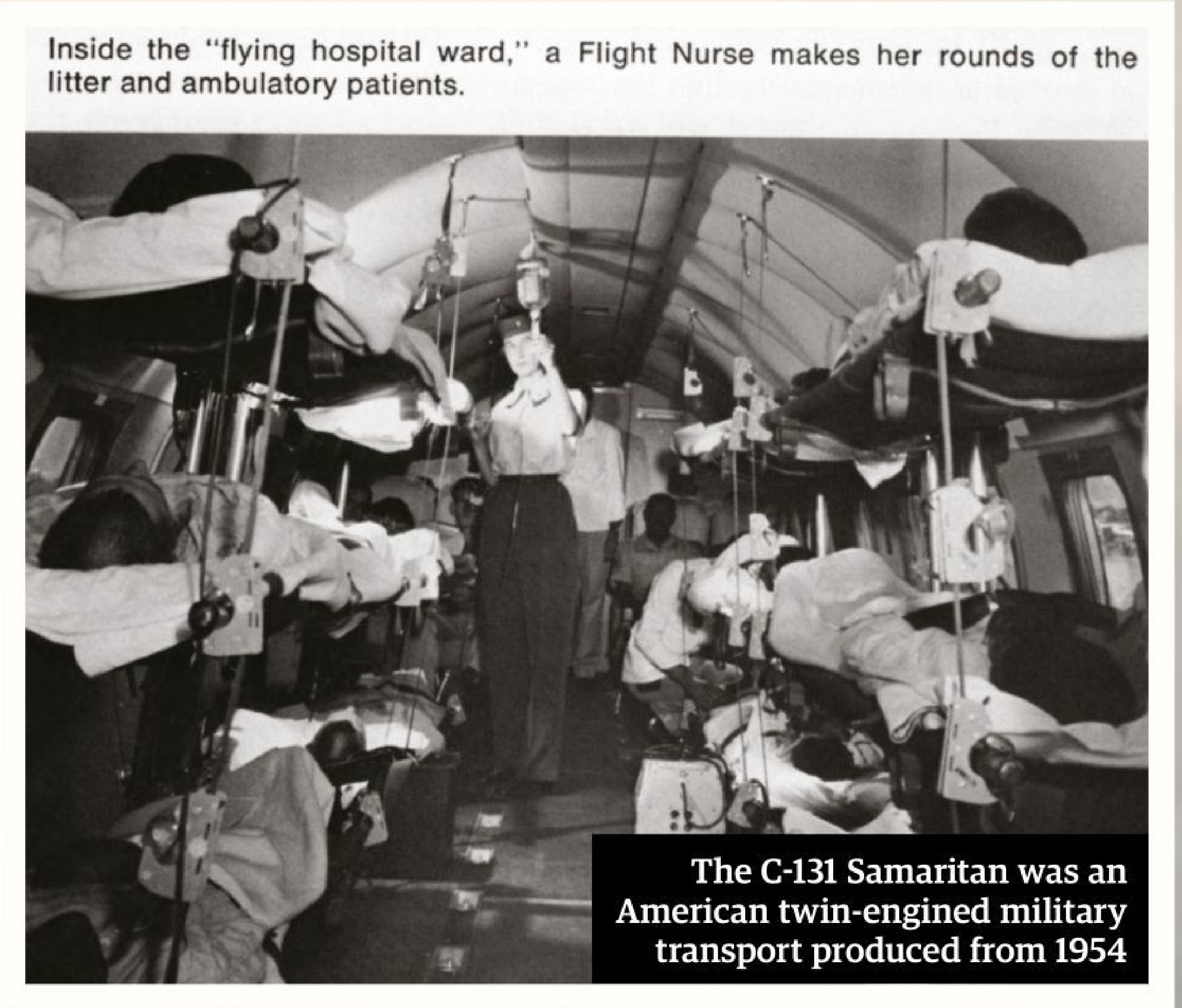
An air-conditioning system was installed aboard the C-54M with controls that could be manipulated by individual patients, providing the circulation of cool or warm air throughout the aircraft. The C-54M was the first aircraft to provide air conditioning that was controlled by the patients, and the system operated efficiently in the air and on the ground.

Wide exit

Already adapted for the loading and unloading of substantial cargo, the exit from the C-54M flying hospital was ideal for the easy movement of patients into and out of the aircraft. At times patients were transported with oxygen and intravenous fluids that were problematic during ingress and egress. However, the wide exit and other design adaptations of the C-54M effectively managed the issue.

Oxygen supply

Critically wounded or sick patients often required oxygen, and the C-54M was equipped with a system that supplied it to individual litter sling positions aboard the aircraft. Without a centrally supplied oxygen system, medical personnel would have been required to operate heavy tanks aboard the plane, taking up valuable space, increasing the in-flight weight of the aircraft and presenting a substantial safety hazard.



Inside the "flying hospital ward," a Flight Nurse makes her rounds of the litter and ambulatory patients.

The C-131 Samaritan was an American twin-engined military transport produced from 1954

© Adrian Mann, Getty Images

DAY IN THE LIFE

A MASH DOCTOR

SAVING SOLDIERS' LIVES ON THE FRONT LINE

KOREA, 1950-53

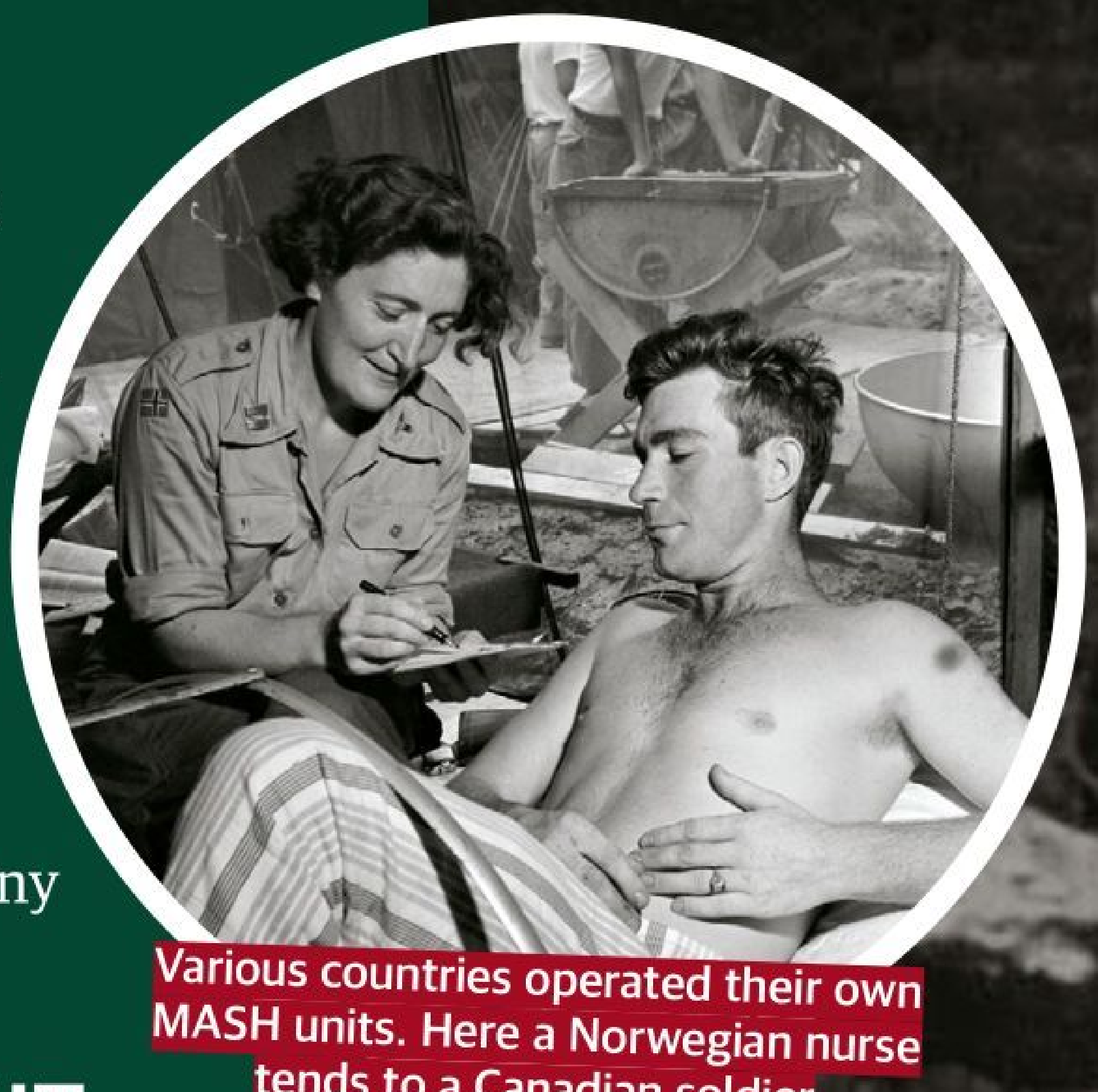
During World War II, soldiers who had been wounded in battle had to be evacuated to fixed field hospitals to receive treatment, but these were often so far away from the front lines that the patient would die en route. By the outbreak of the Korean War in 1950, the need for mobile medical aid was evident, and so the US Army established the first mobile army surgical hospital (MASH). These units could be set up close to the front line relatively quickly and move with it, ensuring soldiers urgently received the medical care they needed to greatly increase their chances of survival. MASH units continued to be used throughout several conflicts, including the Vietnam War, until being decommissioned in 2006.

SET UP

After travelling through the night over tough mountain terrain in hostile territory, trucks loaded with tents, medical supplies and medical personnel would offload their cargo in a suitable setting between six and 16 kilometres from the front line. Here the tents were pitched, and up to 200 hospital beds were set up inside. The entire process took no more than four hours.

RECEIVE PATIENTS

Wounded soldiers were initially taken to battle aide stations, small medical units with limited capabilities located on the front line. At these stations they would receive basic emergency care from general medical officers, before either being returned to duty or evacuated by helicopter to the nearest MASH unit for further treatment. Some units received as many as 1,000 casualties a day.



Various countries operated their own MASH units. Here a Norwegian nurse tends to a Canadian soldier

PRIORITISE TREATMENT

Doctors and nurses at the MASH would assess each new patient using the triage system, determining the priority of treatment based on the severity of their condition. The adopted principle was: "Life takes precedence over limb, function over anatomical defects." Due to the sheer number of patients, the seriously injured were sometimes left to die so that others could be saved.

MASH surgery was often crude but effective, with an impressive patient survival rate

PRE-OP CARE

MASH units were equipped with laboratories and X-ray machines to help with patient diagnosis, but unfortunately they did not have heating or air conditioning. The extremes of temperature experienced near the front lines meant that the staff and patients had to deal with freezing and sweltering conditions, which often made operations difficult and hindered patient recovery times.

SURGERY

Each MASH unit typically had five operating tables – often just stretchers balanced on trestle tables – and was staffed by ten doctors, ten nurses and a few dozen enlisted men. The doctors were usually drafted as residents or interns, and given only three days of formal army medical training before having to perform their first surgery. Most of their training was on the job.

FREE TIME

Although some days were non-stop, with staff working 12-hour shifts to get through the backlog of patients, others were relatively quiet. During their downtime, the doctors and nurses could retreat to their living quarters to rest, read, socialise and even dance. Sometimes more senior doctors took this time to train others in new procedures and treatments.

EVACUATION

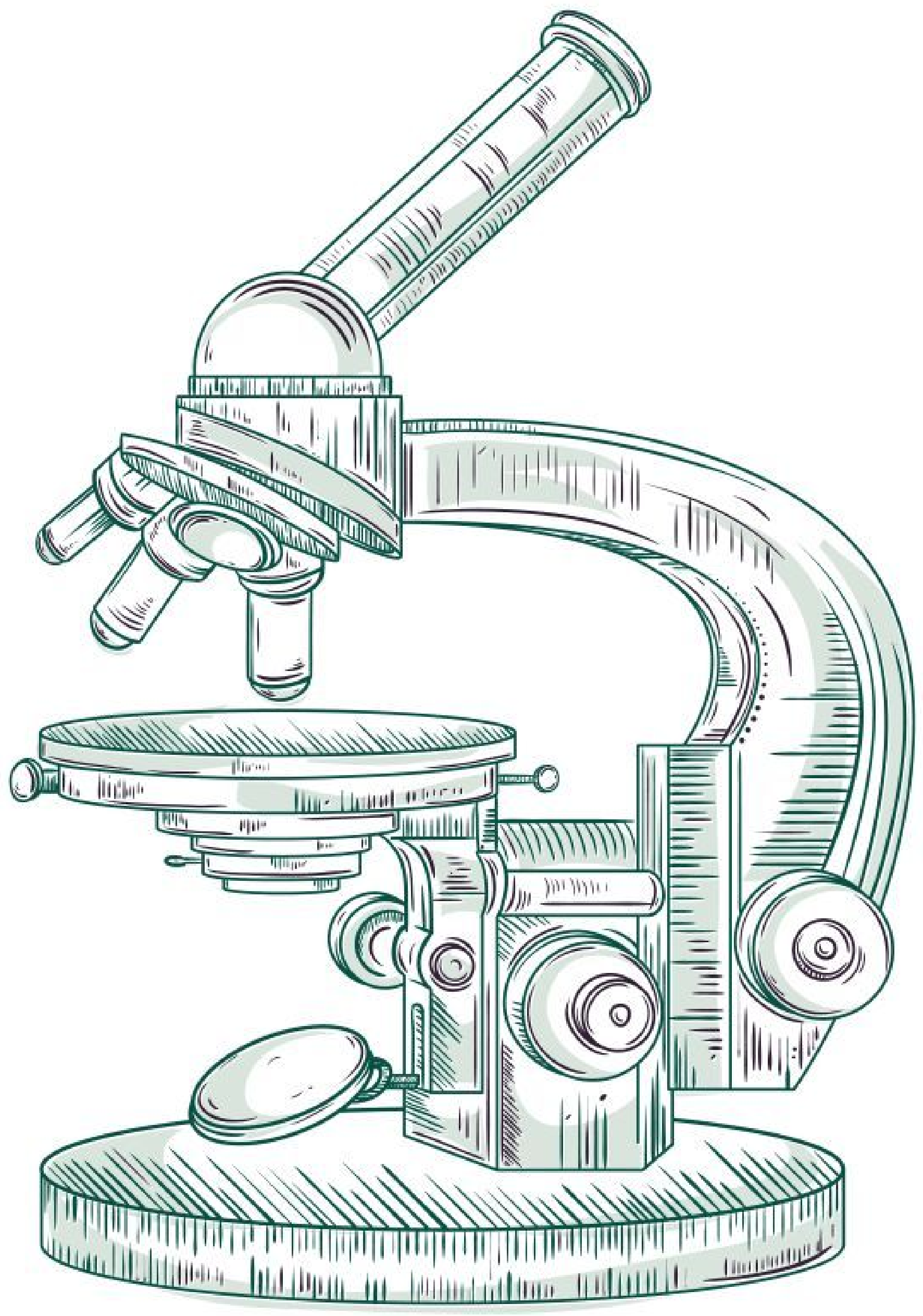
95 per cent of the patients treated by MASH units left them alive. As soon as their condition was considered stable, they would either be returned to duty or evacuated to a permanent hospital for further treatment. Each MASH unit was assigned four helicopters for transporting patients to and from the tents, as well as delivering medical supplies and blood for transfusions.

BUG OUT

As the front line shifted, so did the MASH units. When the order to 'bug out' came, the remaining patients were evacuated, the tents were taken down, the supplies were packed up and everything was loaded onto the trucks, all within six hours. Some hospitals moved once a week on average, while others were able to stay put for around a month at a time.

With both air and road mobility, MASH units could extract men from almost any situaion

© Alamy, Getty Images



MEDICINE SINCE THE MILLENNIUM

From mapping the genome to nanotechnology and advanced treatment for conditions such as HIV and cancer, breakthroughs in 21st-century medicine are occurring all the time

From the earliest days of its existence, humankind has striven to treat illness, pushing the boundaries of care and experimentation in the battle for survival. Whether it is the evidence of trepanation found on Neolithic skulls dating back into the mists of prehistory or modern nanotechnologies that seem more at home in science fiction than the real world, medicine has always been a developing science. With innovations and breakthroughs coming in seemingly rapid succession in the 20th century, researchers, scientists and medics today continue to build on the foundations provided by those discoveries and, aided by developing technologies, the future seems almost limitless

Yet to understand medicine's recent history, we must first look to the more distant past. In the last century, developments in medicine took place that would have been unthinkable just a century before. From 1900 onwards, medical discoveries seemed to be an almost constant part of human advancement. As innovations such as anaesthetic, X-rays and better understanding of disease and lifestyle became commonplace, life expectancy soared, increasing by an average of more than 25 years.

The benefits of this progress were, of course, most felt in the developed world and often by those who had the money to pay for them. Medical developments were aided by the technical leaps and bounds made by other areas of science, technology and communication. Scientists and medics no longer worked in isolation but were able to collaborate and share with increasing ease, learning from and supporting peers in their research.

In the early years of the previous century, a great deal of emphasis was placed on understanding the sources of infection and developing ways to treat it. Surgical developments were needed to deal with the effects of not one but two world wars and as the years passed, the focus shifted from

Syringes are now made
on an industrial scale

> “Infections such as malaria, which were once rampant, are now under control thanks to the work of medical professionals, charities and groups”

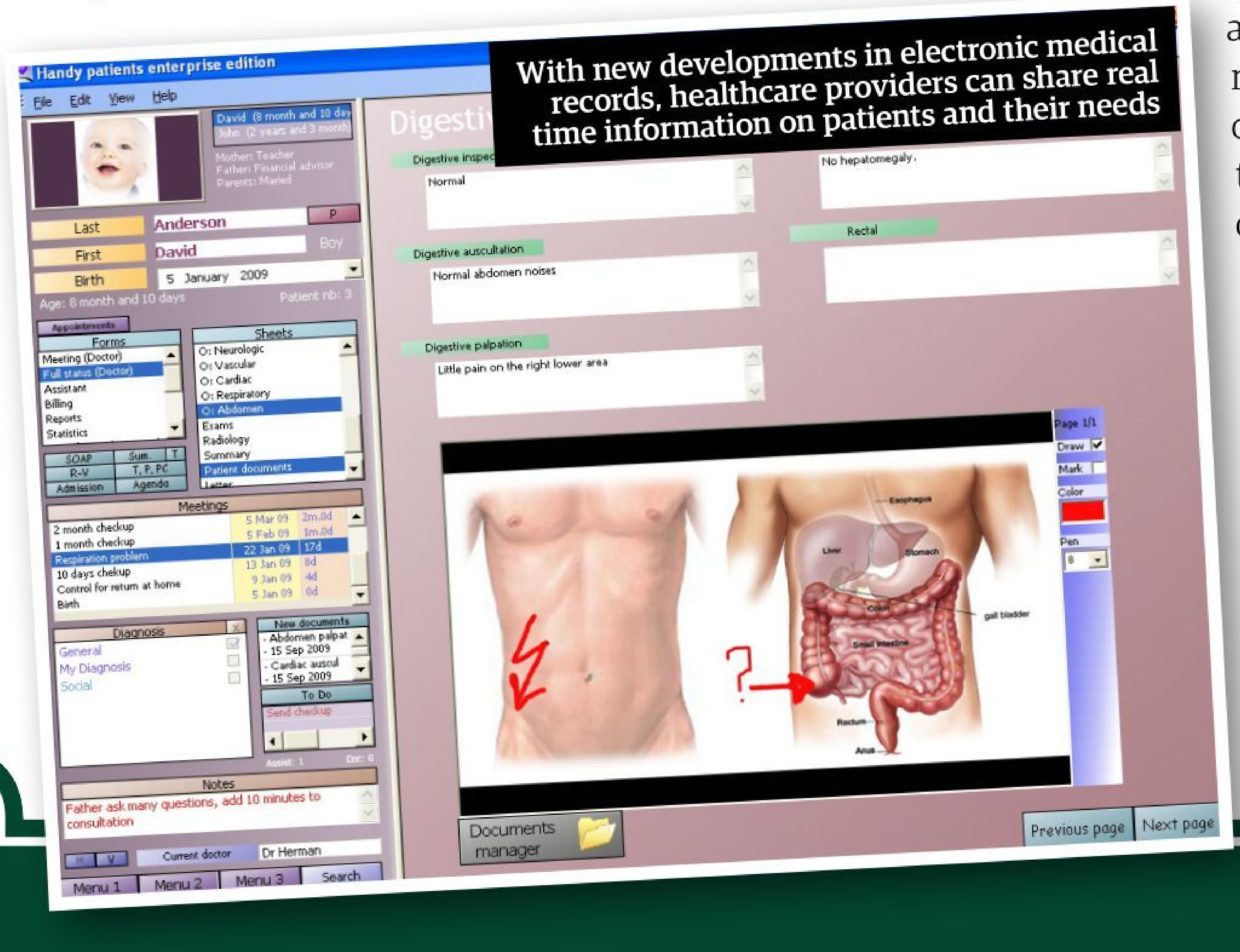
3D printing offers medical researchers the promise of printing organs and, as this skull demonstrates, bones

treating infections and diseases to controlling and preventing them. In a fast-changing world, technological currency is growing ever shorter and today’s pioneering research is swiftly rendered yesterday’s news as it develops and improves at a rapid rate.

Infections that once meant a death sentence have become the stuff of everyday life for those in the developed world. Where once a diagnosis of an illness such as mumps or measles could prove fatal, today they are all part of growing up. The discovery of penicillin in 1928 was the first step on the road to combating the mortal effects of these illnesses and with the development of antibiotics - many previously life-changing illnesses became the childhood inconveniences we recognise today. In the new century, however, these conditions are becoming less prevalent than ever thanks not to their treatments, but to new developments in public health including medical means such as vaccinations, but also education that begins in childhood.

Nowhere is education proving more effective than in the battle against cancer. While early diagnosis, treatment and mortality rates are improving all the time, a focus on lifestyle has become a key part of medicine’s efforts to combat the disease in many of its forms. With highly publicised proven links between an unhealthy lifestyle and cancer, public health programmes have sought to present this evidence as starkly as possible, while legislation has also been invoked in matters such as cigarette packaging, the ban on smoking in public places, and clearer labels on alcoholic drinks, to ensure that no one can doubt the links between such items and disease. With the much-publicised and hotly debated new sugar tax also taking effect, it is an ongoing issue for governments and medical professionals and they aim to press the urgency of the matter on people when they are as young as possible. This extends into education on the part a healthy lifestyle can play in preventing conditions such as heart disease, with food packaging now required to clearly display salt, fat and sugar contents. Indeed, even the packaging itself is subject to legislation, with cancer-causing substances now banned in food manufacture and packaging.

In the developing world, prevention is also proving the preferred route rather than cure. Infections such as malaria, which were once rampant, are now under control thanks to the work of medical professionals, charities and groups including the Red Cross and the World Health Organization, whose work spans the globe, educating and assisting those most at risk. In the laboratories of medical researchers the battle continues, constantly developing the medicines used to battle the challenges faced in the developing world, such as the evolution of the mosquito population’s immunity to vaccines and the vital matter of clean drinking water, among other pressing issues.



With new developments in electronic medical records, healthcare providers can share real time information on patients and their needs

David (8 month and 10 days)
John (2 years and 3 month)
Mother: Teacher
Father: Financial advisor
Parents: Maried
Last: Anderson
First: David
Boy
Birth: 5 January 2009
Age: 8 month and 10 days
Patient nb: 3
Digestive inspection: Normal
No hepatomegaly.
Digestive auscultation: Normal abdomen noises
Rectal
Digestive palpation: Little pain on the right lower area
Notes: Father ask many questions, add 10 minutes to consultation
Current doctor: Dr Herman

Perhaps the most significant surgical developments of previous centuries have been anaesthetic and the understanding of infection control. With anaesthetic came the ability to protect patients against surgical shock during operations while proper sterilisation and preparation of the surgical area and those professionals performing the procedure greatly reduced the risk of often fatal infection. Though any surgery still carries risk, the mortality rate of patients due to general anaesthetic declined from one in 1,000 in the middle to the century to one in 100,000 by the end of it. Yet modern surgery, with its emphasis on efficiency and recovery in a world

ANTIRETROVIRAL TREATMENT FOR HIV

For many years, treatment for people living with HIV required a complex and regimented combination of medications, sometimes numbering more than 30 pills every day. The schedule could be punishing and for those treating HIV in developing nations, it was particularly difficult to adhere to.

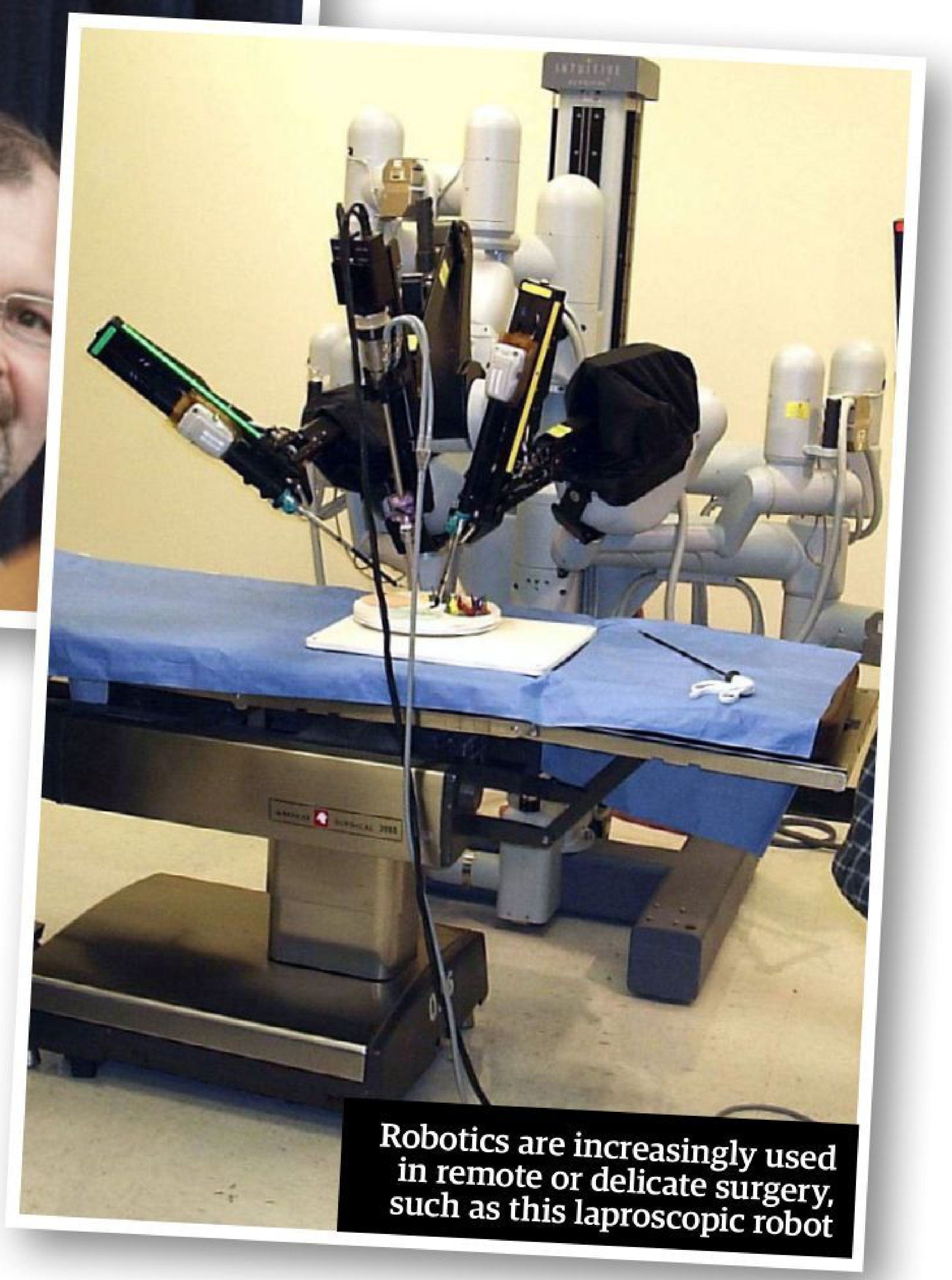
In 2006, a new single pill was approved that combined all the medications into one tablet, revolutionising treatment for those living with HIV. It was a ground-breaking example of collaboration between pharmaceutical companies and one that has made the management of HIV easier for all.

Thanks to developments in HIV therapy, life expectancy is now around 78 years old, and scientists are now working at the cellular level in the hope that they might be able to cut the virus out of the DNA of individual cells, effectively allowing the body to repair itself.

In developing countries, meanwhile, new therapies combine with education programmes to raise awareness of HIV/AIDS prevention, and improve access to treatment for those already living with the condition.

Once managed by sometimes dozens of tablets, HIV medication can now be delivered in a single daily dose

Jim Maki received the first face transplant in the US. He is pictured with his surgeon, Bohdan Pomohac



Robotics are increasingly used in remote or delicate surgery, such as this laproscopic robot

in which hospital space is at a premium, continues to evolve to try and reduce the need for general anaesthetic to a minimum.

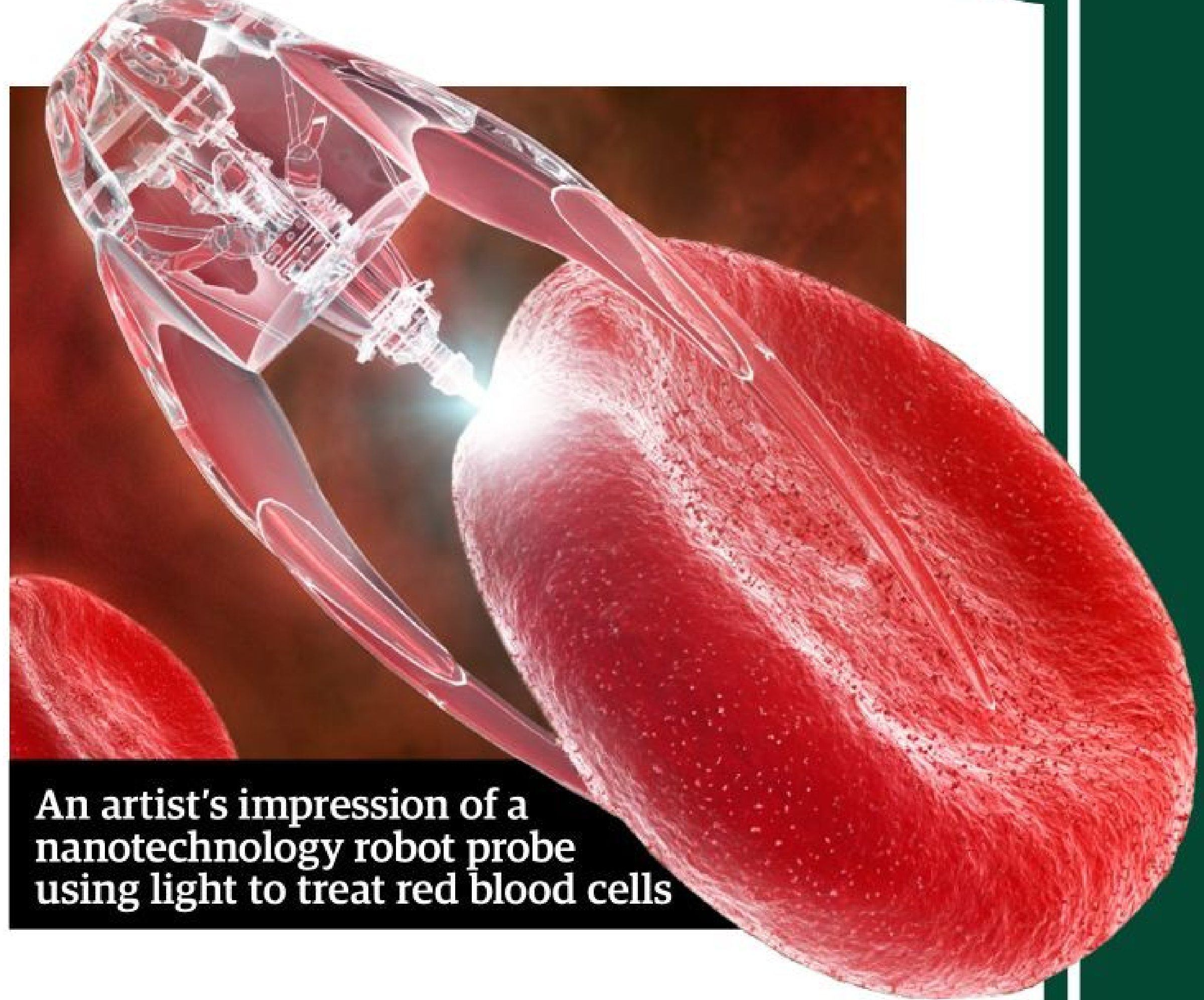
Of course, general anaesthetic remains a must when it comes to heart surgery and organ transplantation, as well as some neurosurgeries. Today these fields are at the forefront of surgical developments and in the 21st century, for the first time, the increasingly common surgery of face transplantation made its debut on the medical stage. Once thought of as the stuff of science fiction, all of that changed when a partial face transplant was carried out in France in 2005. In 2010 Spanish doctors carried out the first full face transplant on a patient who had sustained catastrophic injuries in a shooting accident. The following year French surgeons were once again leading their pioneering field, when they were able to perform a full transplant with tear ducts and eyelids, marking the first time this extensive procedure had been successfully performed. Developments in the field continue to grow and today surgeons are able to use 3D imaging to perfectly shape the donor's face to match the recipient's skull. This means that they can recreate the patient's original face as closely as possible and donor recipients can reasonably expect to live a near normal life once they have recovered.

> Deep-seated beliefs within the field of medicine are constantly being challenged and changed

Facial transplantation is, of course, an area of medicine that carries significant risk, not to mention ethical considerations – frequently the battleground of the modern medical scientist. Patients will be placed on a lifelong regime of immunosuppressants to ensure that their body won't reject the transplant, and these drugs carry with them a risk of cancer. In addition, some candidates for transplant surgery are perfectly healthy but living with significant physical disfigurement that makes a facial transplant an option. In these cases, otherwise healthy people are required to submit to potentially fatal surgeries and aftercare. As with so many areas of modern medicine, there is much to consider in terms of ethics.

Yet with developments such as gene therapy, there may be no need for surgery for some patients at all. This highly controversial research has caught the public imagination like no other. Stem cell research has pointed to the future of medicine as researchers are able to manipulate the individual cells of a patient and reprogramme them, hopefully to control and stop the progression of otherwise fatal or life-limiting conditions. Already successfully used in the treatment of sickle cell disease, gene therapy researchers believe that they will be able to reverse some cancers, eradicating the need for traumatic radiation or chemotherapy treatments, and meaning that patients will not have to undergo invasive surgery. This goes hand in hand with targeted cancer therapies that attack only the diseased cells, as opposed to otherwise healthy cells in the body.

None of this would have been possible without the celebrated breakthrough of 2003 when a team of researchers succeeded in sequencing the human genome. For the first time they were finally able to map the



An artist's impression of a nanotechnology robot probe using light to treat red blood cells

New frontiers in nanomedicine

Nanotechnology allows scientists to work at the molecular level. Simply put, using microscopic tools and devices, they are able to work on individual pieces of cells or DNA or research viruses that are thousands of times smaller than the thickness of a strand of human hair.

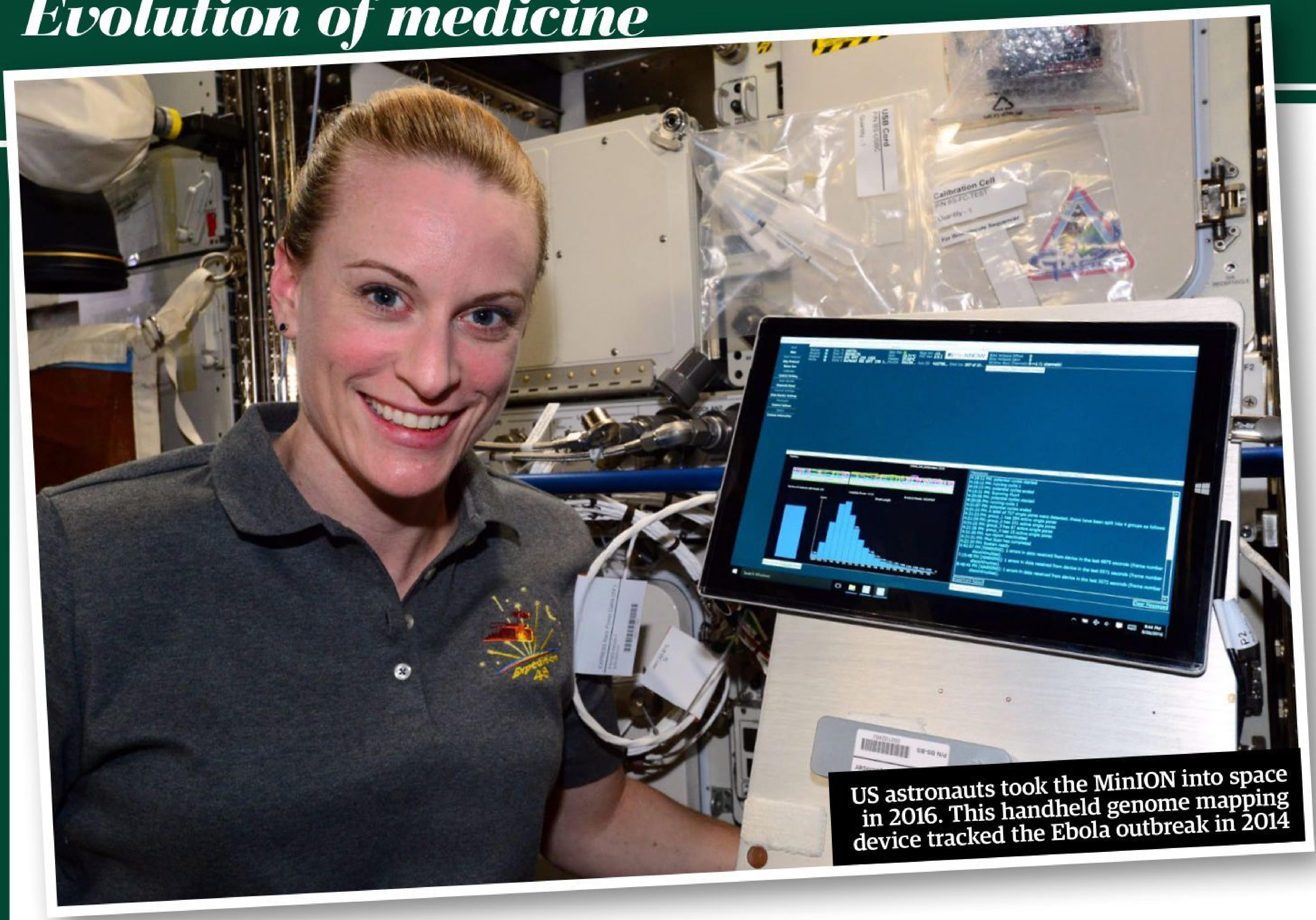
These technologies are giving medical scientists the ability to manipulate parts of our DNA, with the ultimate aim of being able to understand and analyse every individual section and treat patients for any condition that might be found there. Even now researchers are striving to create nanobots, tiny robots that can be programmed to repair damage to even the tiniest piece of DNA, molecule by molecule.

Where drugs are needed to repair a damaged cell, scientists have already proved in principle that they can create 'nanofactories', which would sit on damaged molecules and create the medicine needed as and when it is required.

With uses being developed in the field of medical imaging and technologies that can even be employed to repair damage to the nervous system at the molecular level, the implications of nanomedicine are wide-reaching.

New legislation on cigarette packaging and public smoking demonstrates the focus on prevention over cure in public health initiatives

BENSON & HEDGES
GOLD
Smoking kills
UK DUTY PAID
5014 3306
Smoking clogs the arteries and causes heart attacks and strokes



US astronauts took the MinION into space in 2016. This handheld genome mapping device tracked the Ebola outbreak in 2014

Targeted cancer treatments

Current cancer treatments such as radiation or chemotherapy subject patients to physically debilitating therapies that attack not only cancerous cells, but healthy ones too. 21st-century scientists have been able to fingerprint individual cancers and analyse them, allowing them to understand which treatment will be most effective on each type of cancer.

In tandem with this, targeted therapies are being developed in the form of drugs that block the growth of tumours or seek out and destroy the cancer cells themselves. Although targeted cancer therapies are now available to patients, not every cancer is suitable for this treatment. In addition, some cancer cells are able to mutate and develop resistance to the drugs, rendering them ineffective.

Targeted cancer drugs are often paired with chemotherapy and research is ongoing to increase the efficacy of the drugs, as well as to better understand how cancers are able to mutate, thus allowing medicine to develop with the mutation and continue to fight the cancer.

Targeted cancer therapies allow treatments to be focused on the individual cancer cells, such as this lymphoma cell

3 billion genes that make up our DNA and the implications of this have been enormous. Now researchers are able to look at cells on an individual basis and identify those that might cause disease. This means that those at risk don't have to wait until they fall ill to seek treatment but can instead use preventative measures.

From enormous laboratories filled with researchers in the 1990s, research into the human genome can now be carried out using a simple handheld device and app that can be taken all over the world. This device was used in West Africa to track and predict the spread of the 2015 Ebola outbreak, allowing medics to diagnose patients within an hour and begin treatment where necessary. The same technology is being applied to tracking and treating the Zika virus and malaria without the need for costly and time-consuming mobile laboratories. It allows efficient, reactive care that can reach even the most inaccessible and remote areas.

Members of the team who mapped the human genome have already been able to create synthetic cells and are working on ways to incorporate this new technology into healthcare. Theoretically, if scientists are able to synthetically create different strains of disease and mutate them, they will be able to have treatments ready and waiting to combat mutating infections, or even be able to find ways to eradicate the mutation altogether. Ultimately it is hoped that stem cell and genome research will enable people to have a personalised preventive treatment programme that reduces the need for surgery or other post-diagnosis treatments to a bare minimum.

Manufacturing technologies that might not immediately seem to have a medical application, such as 3D printing, are even now being utilised in furthering the possibilities for areas such as transplantation and surgery. Researchers have already been successful in printing not only bone structures and blood vessels but even a working human ear. More recently they have printed skin cells that can be grafted onto wounds to promote healing and now they are pushing the boundaries of the technology and striving to print fully functional human organs that can be used in transplant surgery, a field where demand has always far outstripped supply.

Where surgery is unavoidable, new technologies are allowing surgeons to focus their efforts with far more precision, avoiding traumatic procedures in many cases. The increased use in robotics in surgery points towards the future direction of medicine, as the robotic arm that was first debuted in the 1960s can now be seen in its 21st-century guise performing some surgical procedures.

Robotic surgery is highly precise and minimally invasive. With the possibility for smaller incisions and greater magnification offered by this technology, surgeons are able to remove only the diseased or damaged tissue, leaving healthy tissue virtually untouched, while blood loss can be kept to a minimum too. The precision of robotic surgery has also led to groups of patients who might otherwise have been excluded now being able to enjoy life-saving transplant. For instance, patients who required kidney transplants but were considered obese were previously unable to undergo the surgery. In 2009, that changed when Americans physicians carried out a robotic transplant on an obese patient, a procedure that has since been repeated in over 100 candidates.

With less trauma comes quicker recovery times, which is not only an enormous benefit for the patient, but also to the coffers of healthcare providers. This is a subject of some debate given the huge outlay of purchasing a surgical robot and training medical professionals to use it. The cost per procedure is high and operations can be very time-consuming. Though patients have expressed almost

In the 21st century, there is an increased focus on promoting a healthy lifestyle to prevent rather than treat illness

> “New technologies are allowing surgeons to focus their efforts with far more precision, avoiding traumatic procedures in many cases”

universal satisfaction with the reduced pain and recovery time from robotic procedures, with healthcare budgets already stretched in some territories, it is a technology that has yet to enter widespread usage.

Robotics are not just used in surgery, but are increasingly becoming part of everyday life for some patients. Using complex biosensors that read nervous signals, robotic limbs are slowly emerging in the field of medical prosthetics. Both prosthetic arms and legs have been developed for use by amputees while prosthetic hands are now in existence that have five individually jointed and moving fingers, offering an almost full range of movements. Today researchers are working on prosthetics that can be directly controlled by the nervous system and be attached as permanent devices to the user, making the bionic human a distinct possibility!

In developing nations the World Health Organization provides health care and education to professionals and public

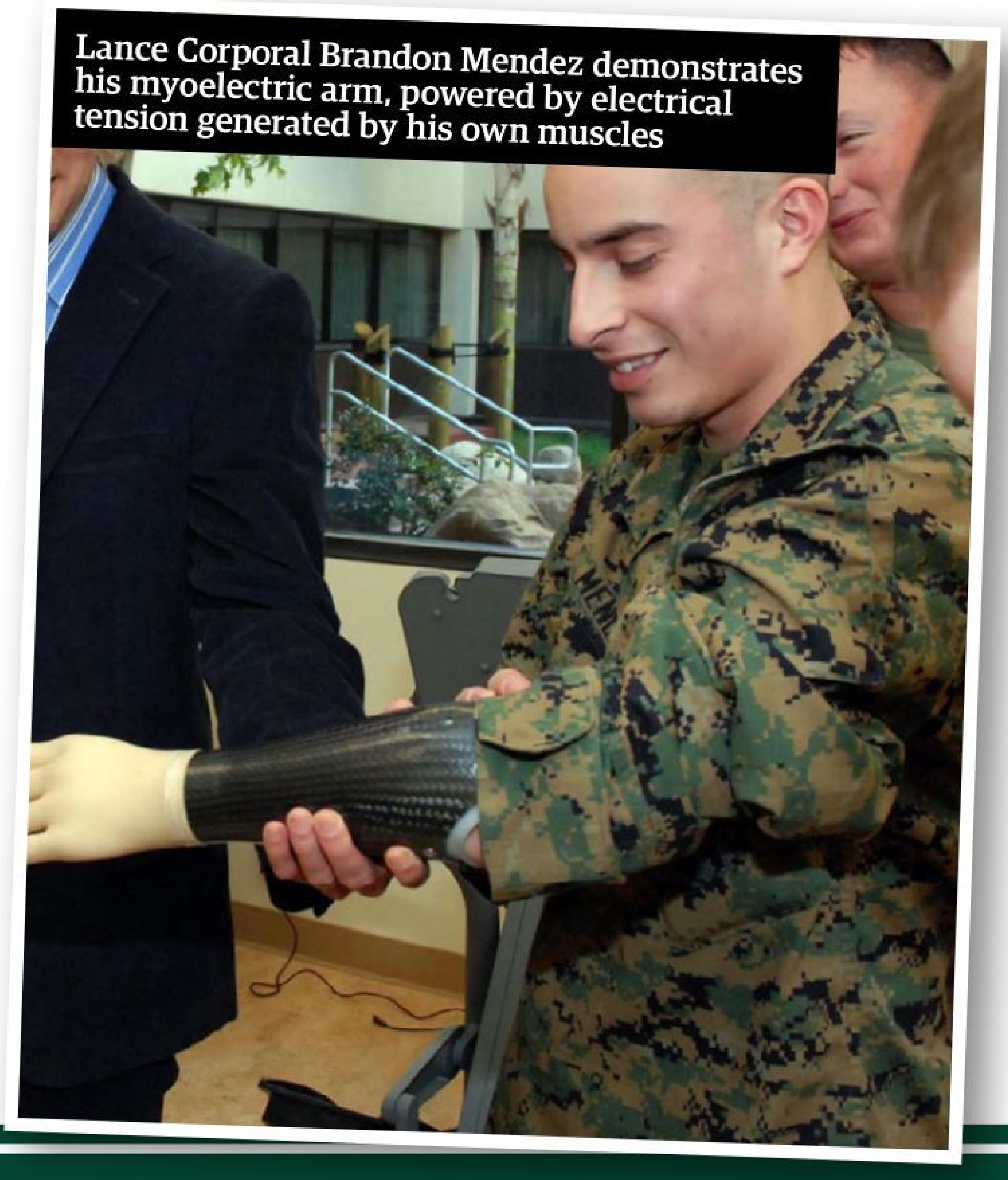
Yet technology in the medical field isn't limited to surgery and prosthetics, and some of the most pioneering advances are too small for the human eye to see. Nanotechnologies can now be employed that work at the molecular level, delivering therapies and medications to individual cells or making the results of MRI scans far more clear and precise than ever before.

On a more everyday scale, new technologies have changed the way in which medical records are kept. Electronic records that can be shared across providers mean that the possibility of human error is vastly reduced. With just a few keystrokes, medical professionals can instantly access and update a patient's history, allowing them to fully understand the needs and history of those they are treating.

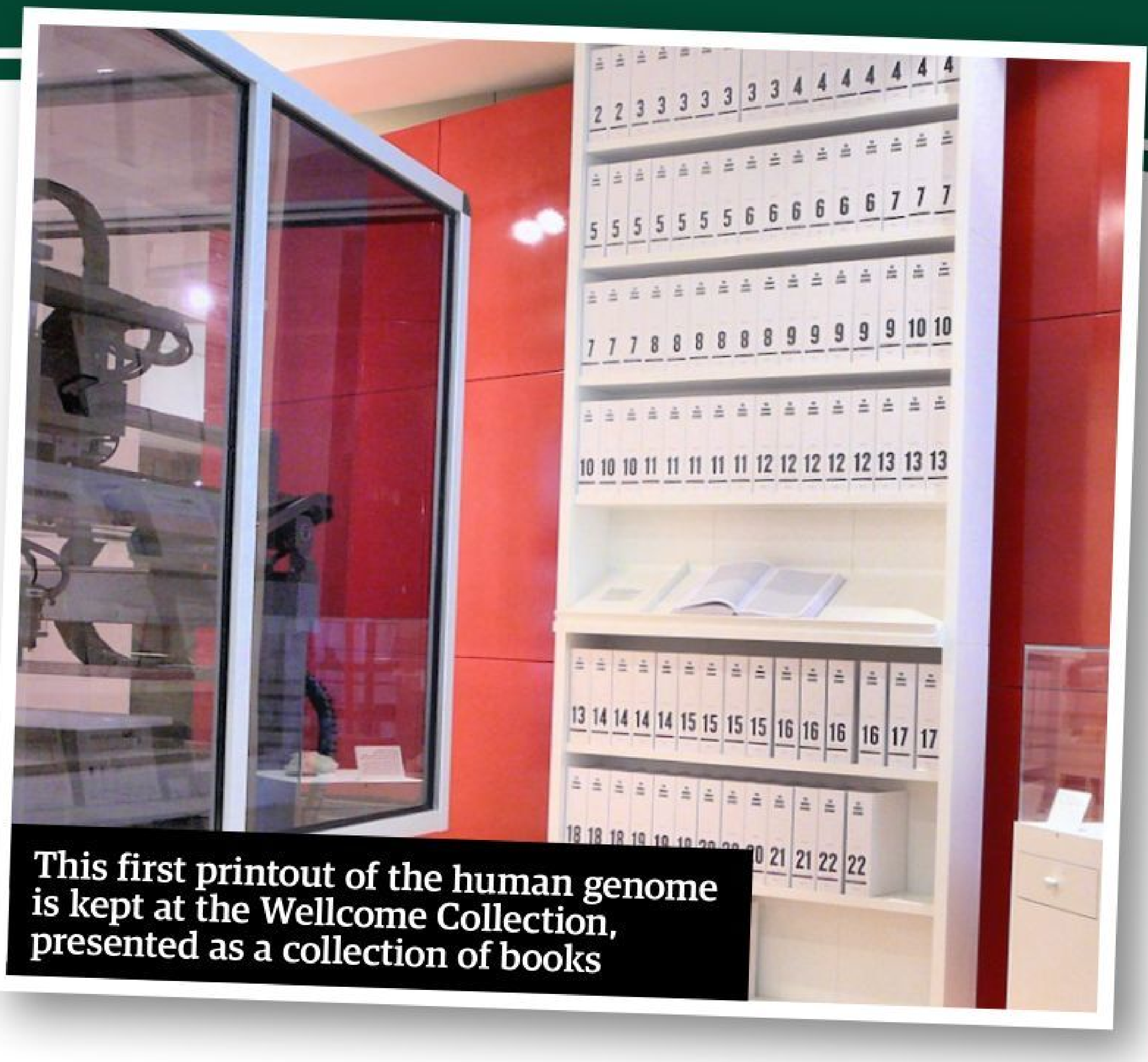
Of course, all healthcare is not equal and while people in developed nations are able to benefit from the most up to date procedures either at cost or, in the case of the National Health Service, free at the point of delivery, for those in the developing world, things are unfortunately not so simple. Yet with prevention and education at the forefront of medicine, access to healthcare and education in those nations is improving all the time.

Today researchers understand the human body and the challenges it faces both from external and internal influences better than ever before. That understanding is in turn allowing patients in the 21st century to experience better survival and recovery rates than ever. Not only that, but in a world where medical scientists can understand the very building blocks of life, it offers the opportunity not only to battle illness and disease, but to act against it before it even has a chance to develop. Yet with these significant leaps forward, there have never been more ethical and controversial issues to navigate and it's likely that these will only increase in the future.

In the developed world, the focus is shifting from cure to prevention and the simple steps that can be taken to maintain a healthy lifestyle, while in the developing world new technologies and medicines are allowing treatment and education to reach more of the communities where it is most needed. For medical science, the future is here.



Lance Corporal Brandon Mendez demonstrates his myoelectric arm, powered by electrical tension generated by his own muscles

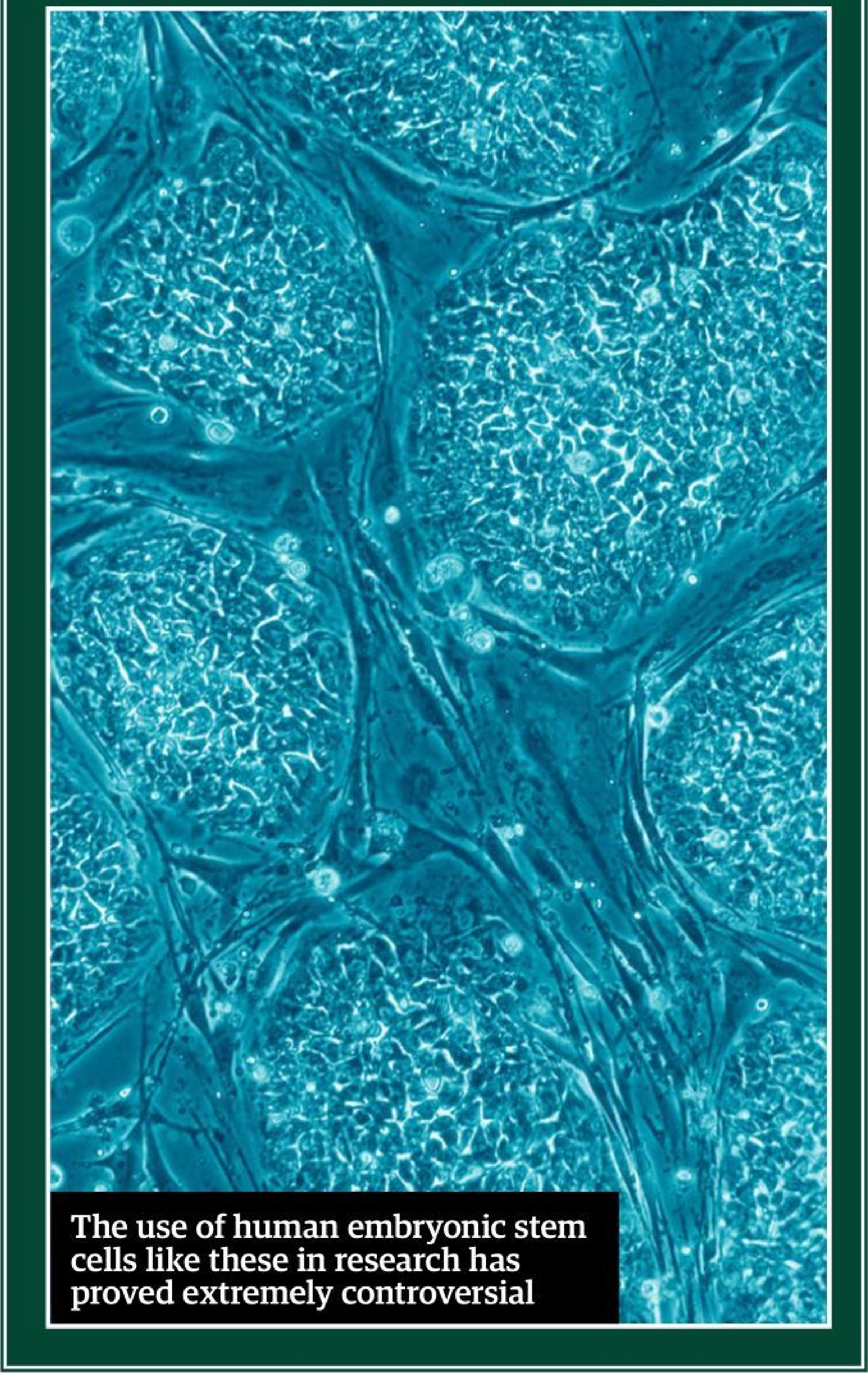


This first printout of the human genome is kept at the Wellcome Collection, presented as a collection of books

STEM CELL RESEARCH

Stem cells, which can renew themselves by division, can be reprogrammed to become another type of cell. This means that they can be turned into tissue-specific cells and used to repair damaged tissue. With a constant need for more organs for transplant, stem cell research offers the possibility of repairing organs without the need for such surgery. The use of stem cells in gene therapy would involve the insertion of healthy genes into a body using a host virus, that would carry the cells to the point at which they are required.

Stem cell research is highly controversial due to the implications of embryonic stem cells, in which scientists carry out experiments on cells that could, in different circumstances, have developed into human beings. Because of this, a number of states in the USA have banned it completely, as have some European nations. However, research is ongoing into gene therapy that would employ stem cells to battle conditions that are currently considered to be incurable.



The use of human embryonic stem cells like these in research has proved extremely controversial

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MEDICAL PIONEERS

Meet the best and brightest revolutionaries who, through relentless study and at times extreme experimentation, changed the field of medicine

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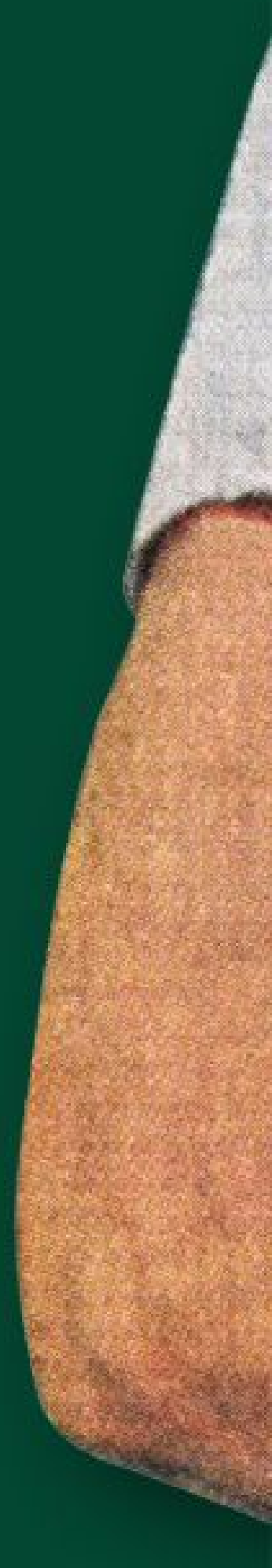

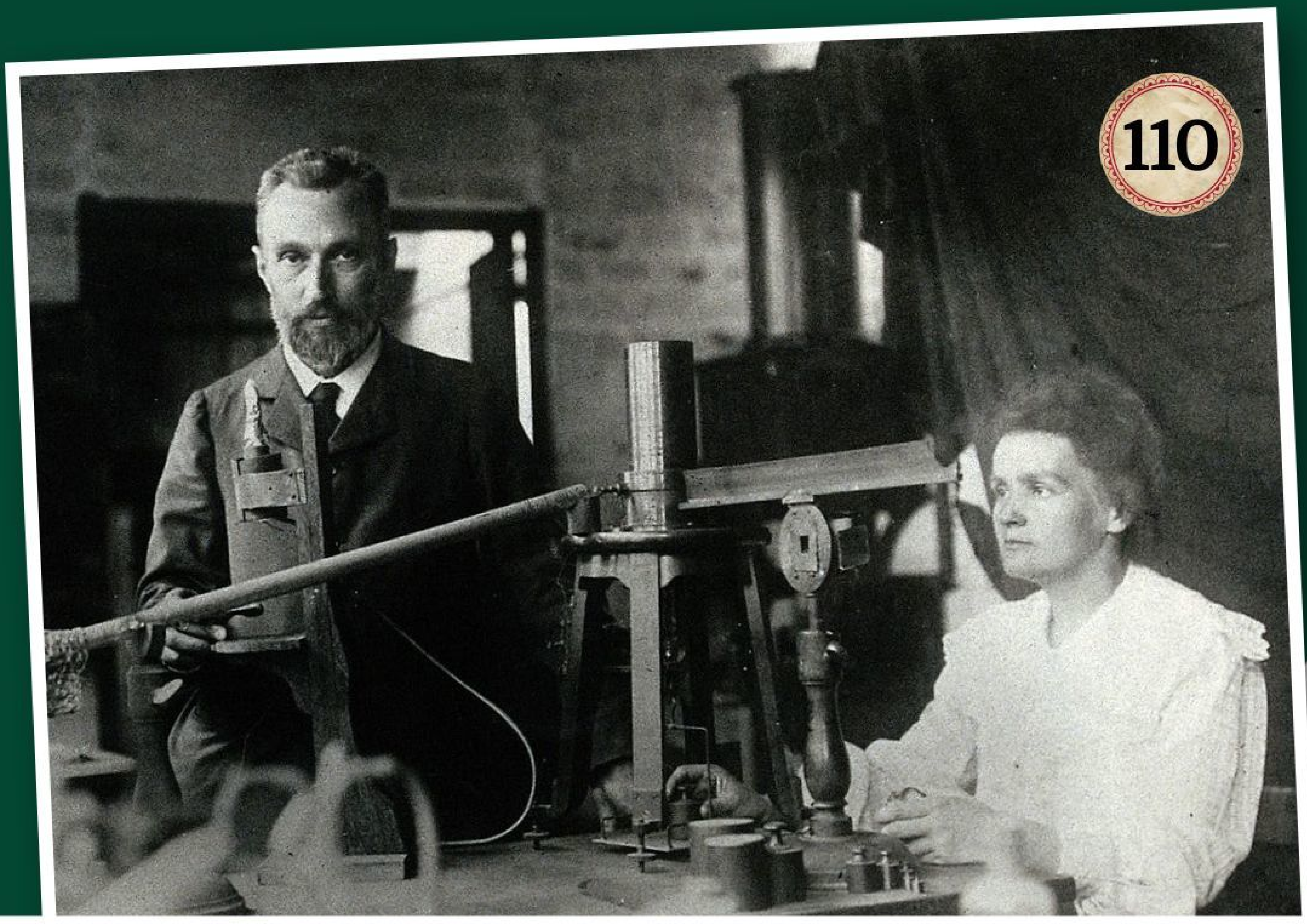
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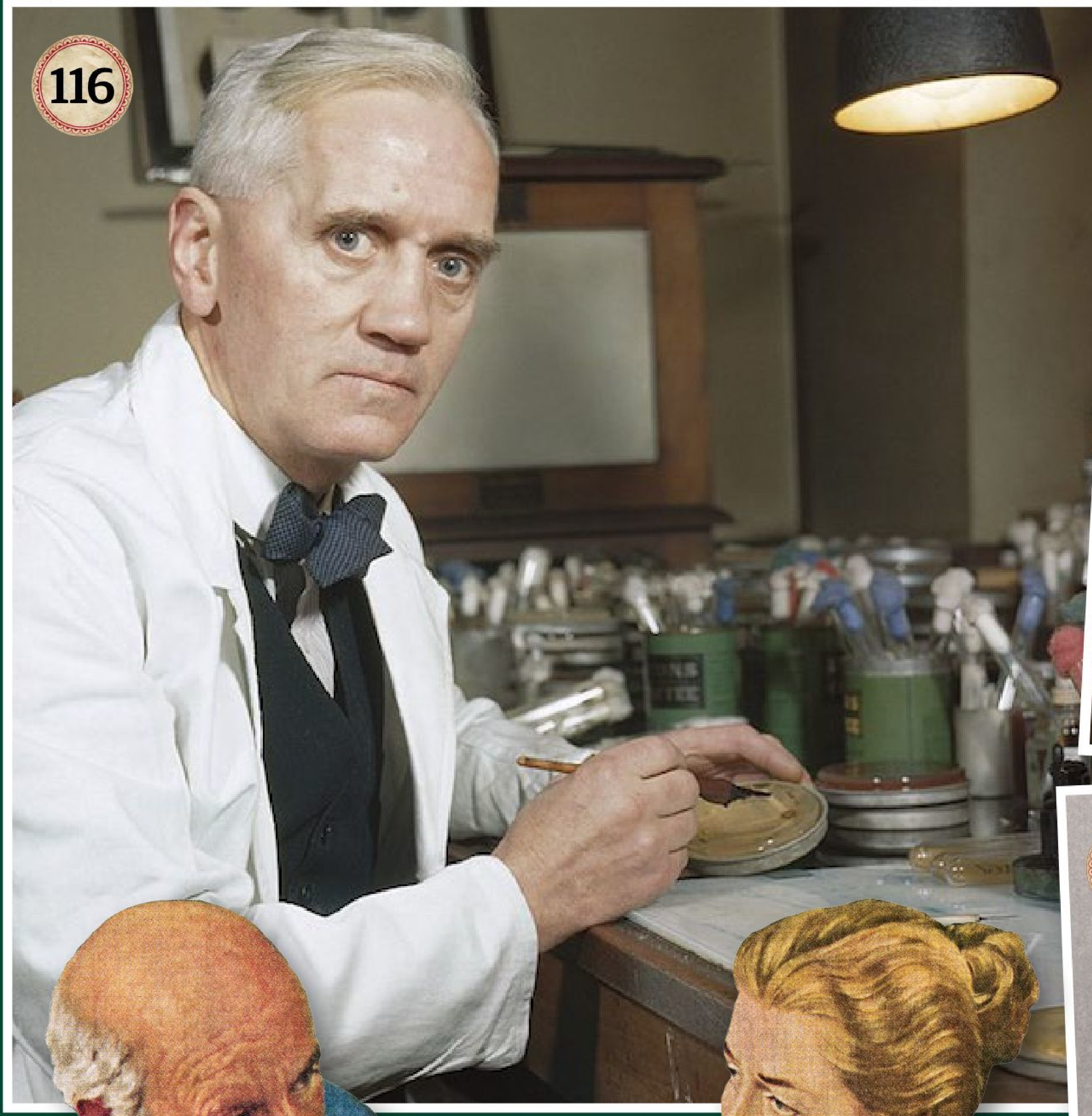
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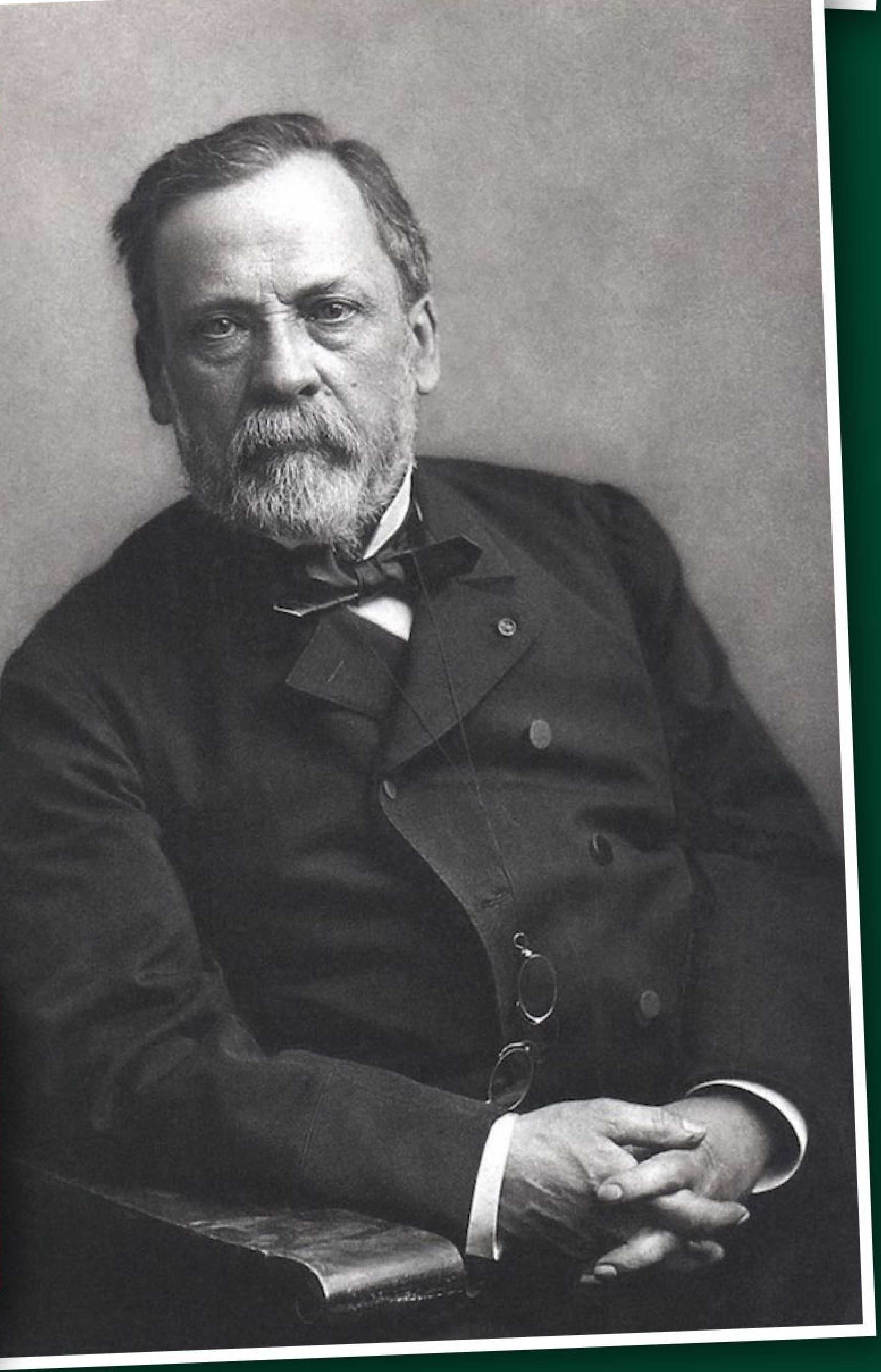
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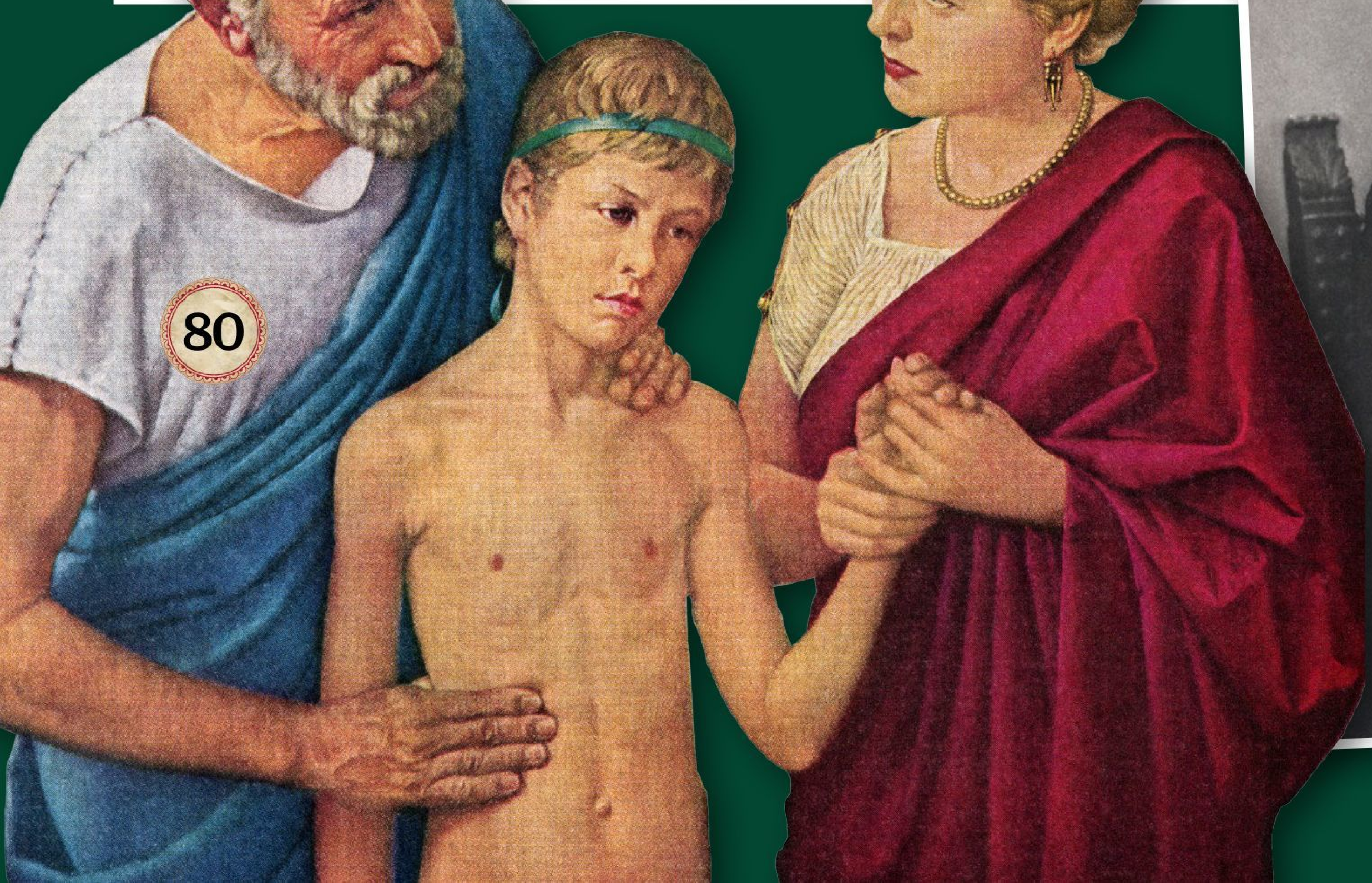
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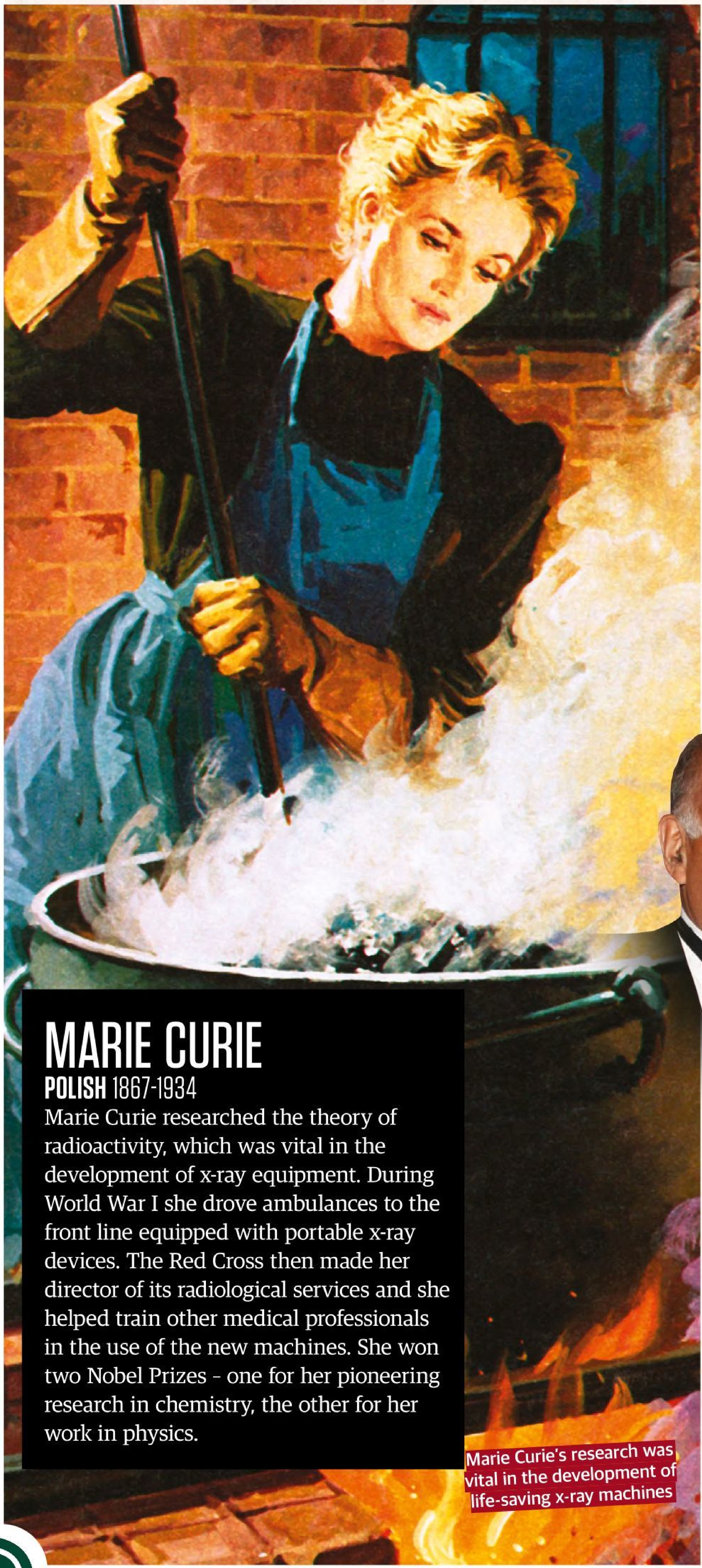
HALL OF FAME

10 PIONEERS OF MEDICINE

Meet those whose inventions, bravery and ingenuity have saved millions

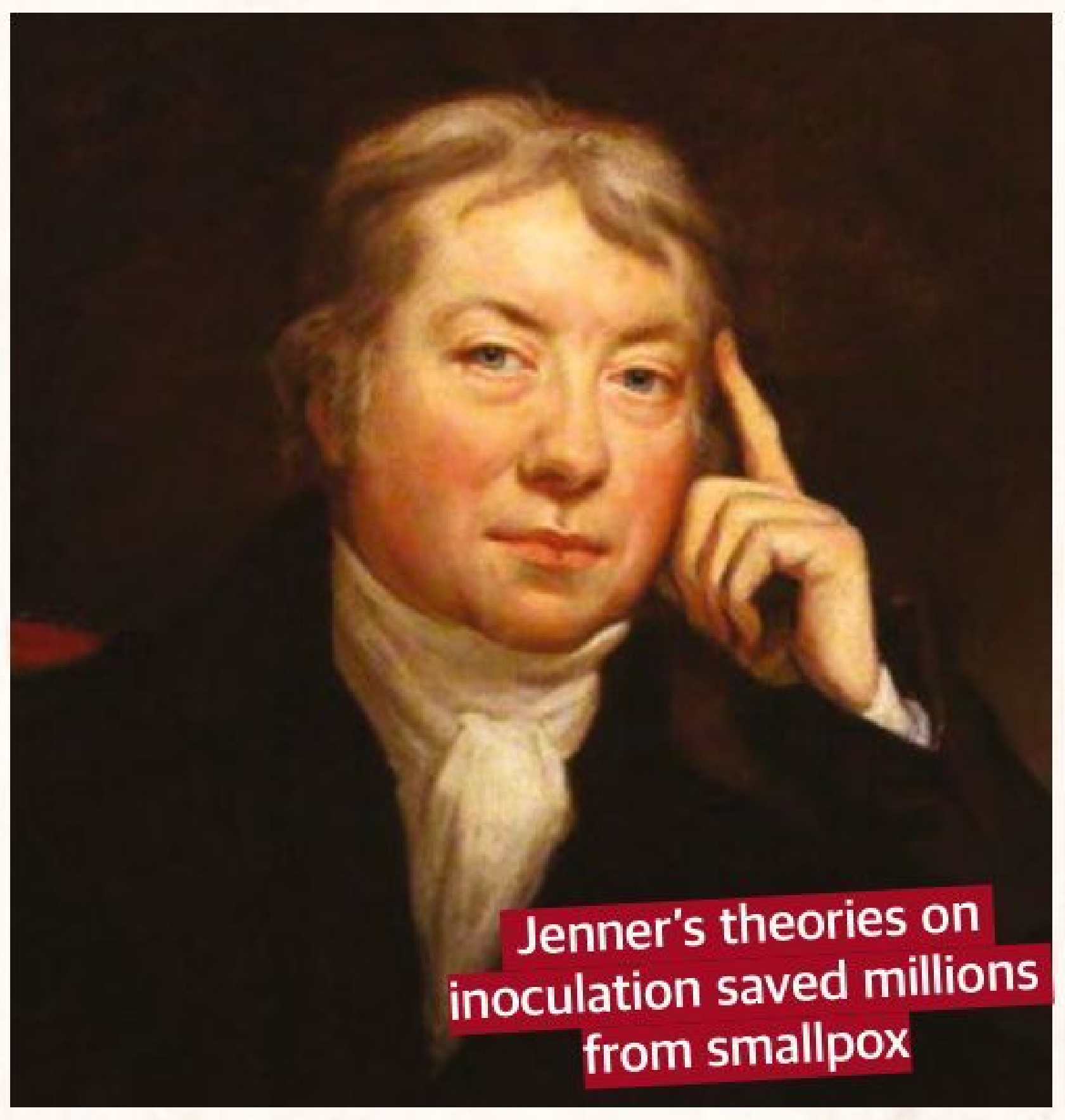


MARIE CURIE

POLISH 1867-1934

Marie Curie researched the theory of radioactivity, which was vital in the development of x-ray equipment. During World War I she drove ambulances to the front line equipped with portable x-ray devices. The Red Cross then made her director of its radiological services and she helped train other medical professionals in the use of the new machines. She won two Nobel Prizes – one for her pioneering research in chemistry, the other for her work in physics.

Marie Curie's research was vital in the development of life-saving x-ray machines

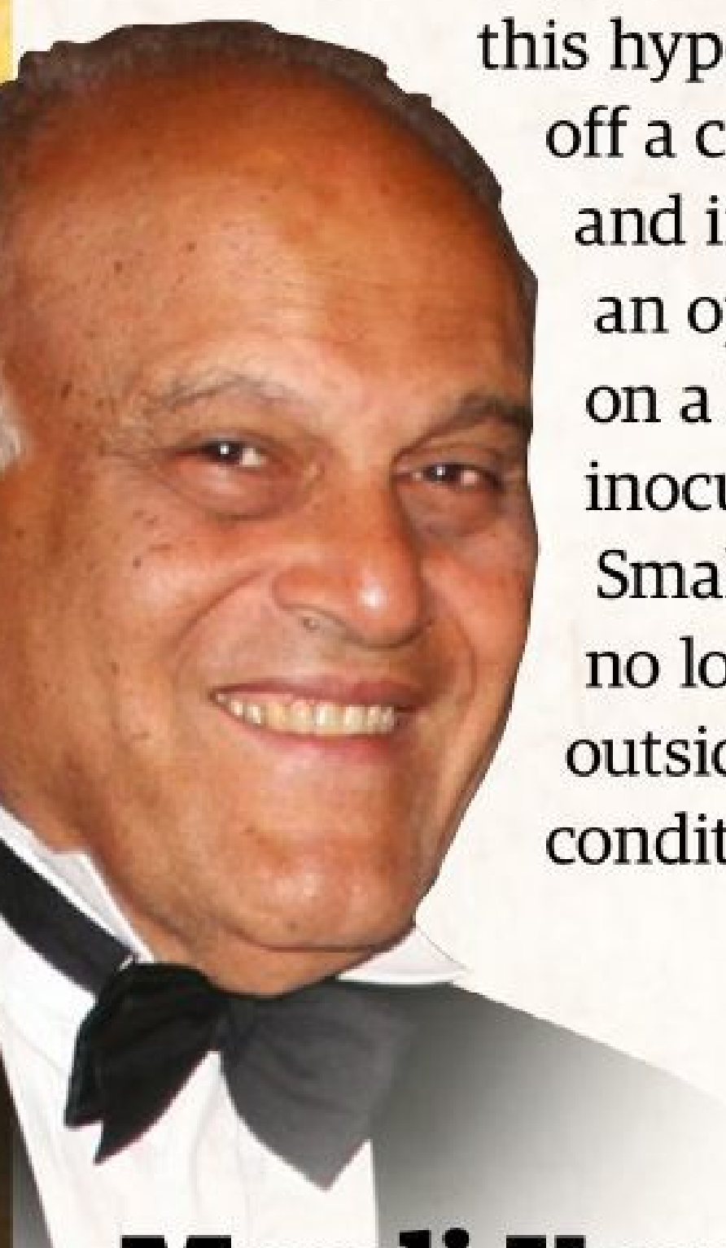


Jenner's theories on inoculation saved millions from smallpox

Edward Jenner

ENGLISH 1749-1823

Known as the 'father of immunology', Edward Jenner has a well-deserved entry into the medicine hall of fame. Not only did he develop the scientific method of immunology, he also discovered the smallpox vaccine by observing that milk maids in England rarely contracted the disease. He realised this was because they had contracted the less-deadly cow pox and as a result had developed natural immunity to smallpox. He experimented with this hypothesis, scraping puss off a cow pox blister and introducing it to an open wound on a boy's arm, inoculating him. Smallpox now no longer exists outside of lab conditions.



Magdi Yacoub

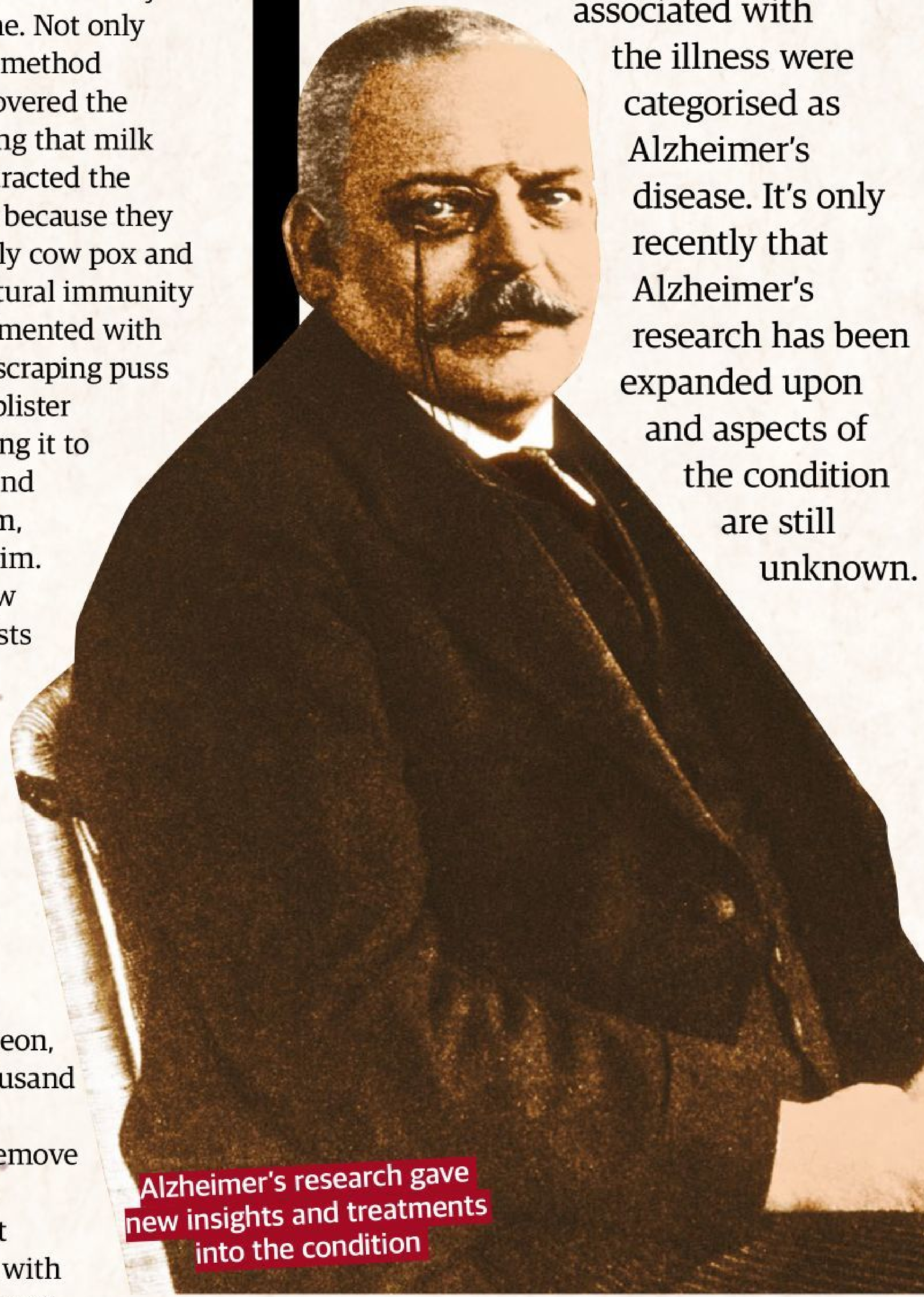
EGYPTIAN 1935-PRESENT

Magdi Yacoub is the world's leading heart-transplant surgeon, having performed over a thousand such procedures. As well as pioneering key methods to remove the organ during surgery, he was the first to conduct heart transplants in the UK. Along with his team of doctors, he grew part of a human heart valve from stem cells, paving the way for increased availability of human organs. He believes in the right to medical care for all and is a key founder of the Chain of Hope charity, which delivers cardiothoracic surgical care to developing countries.

ALOIS ALZHEIMER

GERMAN 1864-1915

Alois Alzheimer first discovered the mental disorder that now bears his name in 1906, when he was director of the Frankfurt clinic for mental illness. He noticed that one of the admitted patients was suffering from short-term memory loss, hallucinations and the loss of her higher mental functions. After she died, her body was autopsied and Alzheimer noticed a thinning of the cerebral cortex and changes in the nerve cells. After further research on similar cases, the problems associated with the illness were categorised as Alzheimer's disease. It's only recently that Alzheimer's research has been expanded upon and aspects of the condition are still unknown.



Alzheimer's research gave new insights and treatments into the condition

> "Nothing in life is to be feared, it is only to be understood"
>
> ***Marie Curie***

Henry Gray

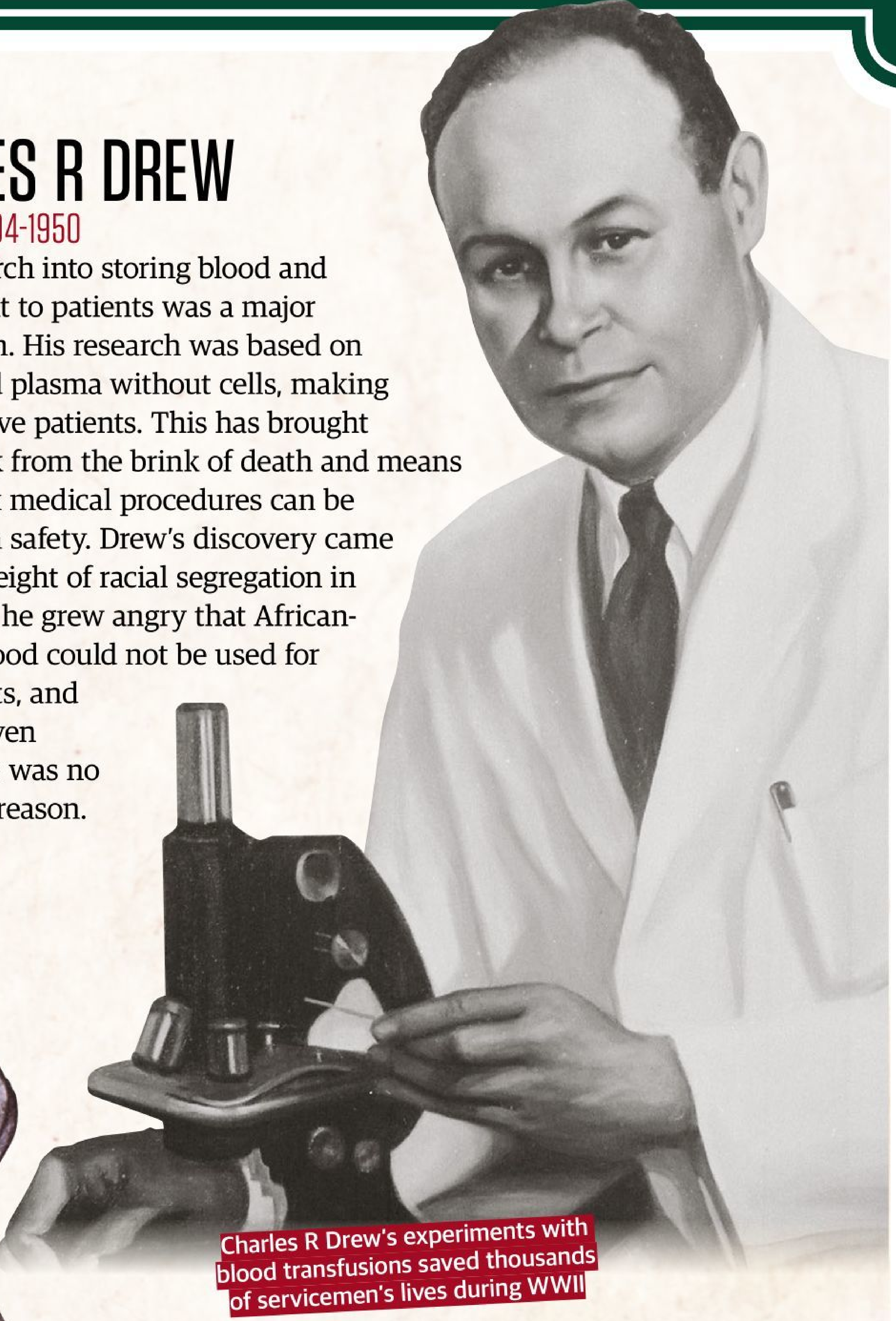
ENGLISH 1827-1861

Gray's Anatomy is seen as a standard text for any first-year medical student. Henry Gray wrote the encyclopedic guide to medical science in 1858, drawing the illustrations himself using bones and other material preserved from corpses as a guide. It was for this reason that the *Anatomy* was far more accurate than anything else that was available at the time. He also wrote a number of other essays, including the distribution of nerves in the eyes of animals. The amount of time he took painstakingly dissecting every part of the specimen to uncover its true nature was legendary. He tragically died at the age of 34 after contracting smallpox from his nephew.

CHARLES R DREW

AMERICAN 1904-1950

Drew's research into storing blood and transferring it to patients was a major breakthrough. His research was based on storing blood plasma without cells, making it ready for live patients. This has brought patients back from the brink of death and means that complex medical procedures can be performed in safety. Drew's discovery came during the height of racial segregation in the USA and he grew angry that African-American blood could not be used for white patients, and vice versa, even though there was no medical reason.



Charles R Drew's experiments with blood transfusions saved thousands of servicemen's lives during WWII

Avicenna

PERSIAN 980-1037CE

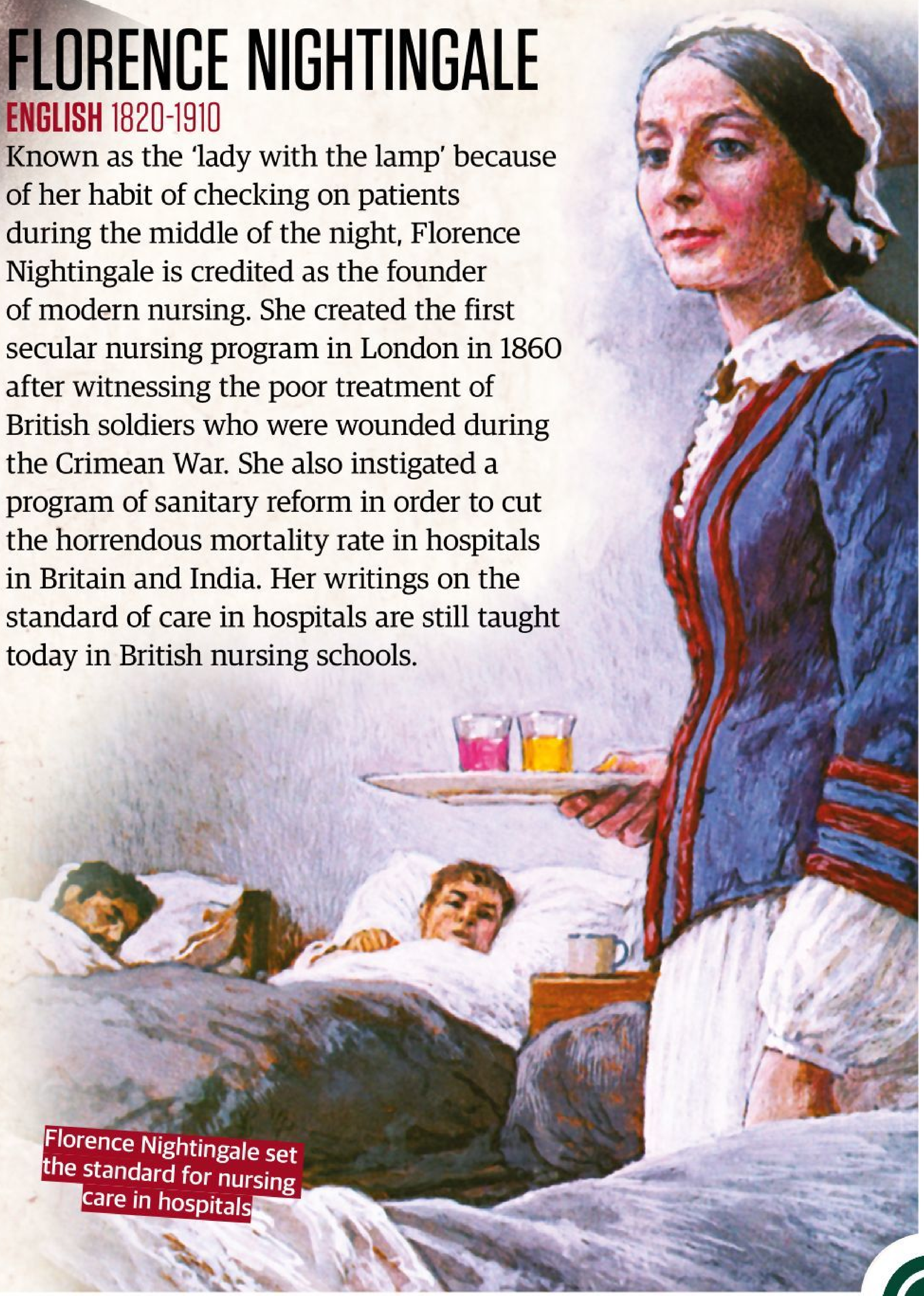
Widely regarded as one of the first medical practitioners, Avicenna combined philosophical teachings with medical knowledge. The *Canon of Medicine* that he wrote and compiled was translated into Latin and found its way into the libraries of Europe, informing students of medicine thousands of miles from his homeland of Persia. The *Canon* commented on the need for quarantine of infectious people and mentioned bad odours in the air and their risk to normal bodily functions. While most of the advice within the *Canon* has now been debunked by modern medical science, the strides Avicenna made in turning medicine from a mystical art to a regulated practise were huge for the time period.

Avicenna wrote about quarantine and the effects of bad odours on health

FLORENCE NIGHTINGALE

ENGLISH 1820-1910

Known as the 'lady with the lamp' because of her habit of checking on patients during the middle of the night, Florence Nightingale is credited as the founder of modern nursing. She created the first secular nursing program in London in 1860 after witnessing the poor treatment of British soldiers who were wounded during the Crimean War. She also instigated a program of sanitary reform in order to cut the horrendous mortality rate in hospitals in Britain and India. Her writings on the standard of care in hospitals are still taught today in British nursing schools.



Florence Nightingale set the standard for nursing care in hospitals

Carl Wood

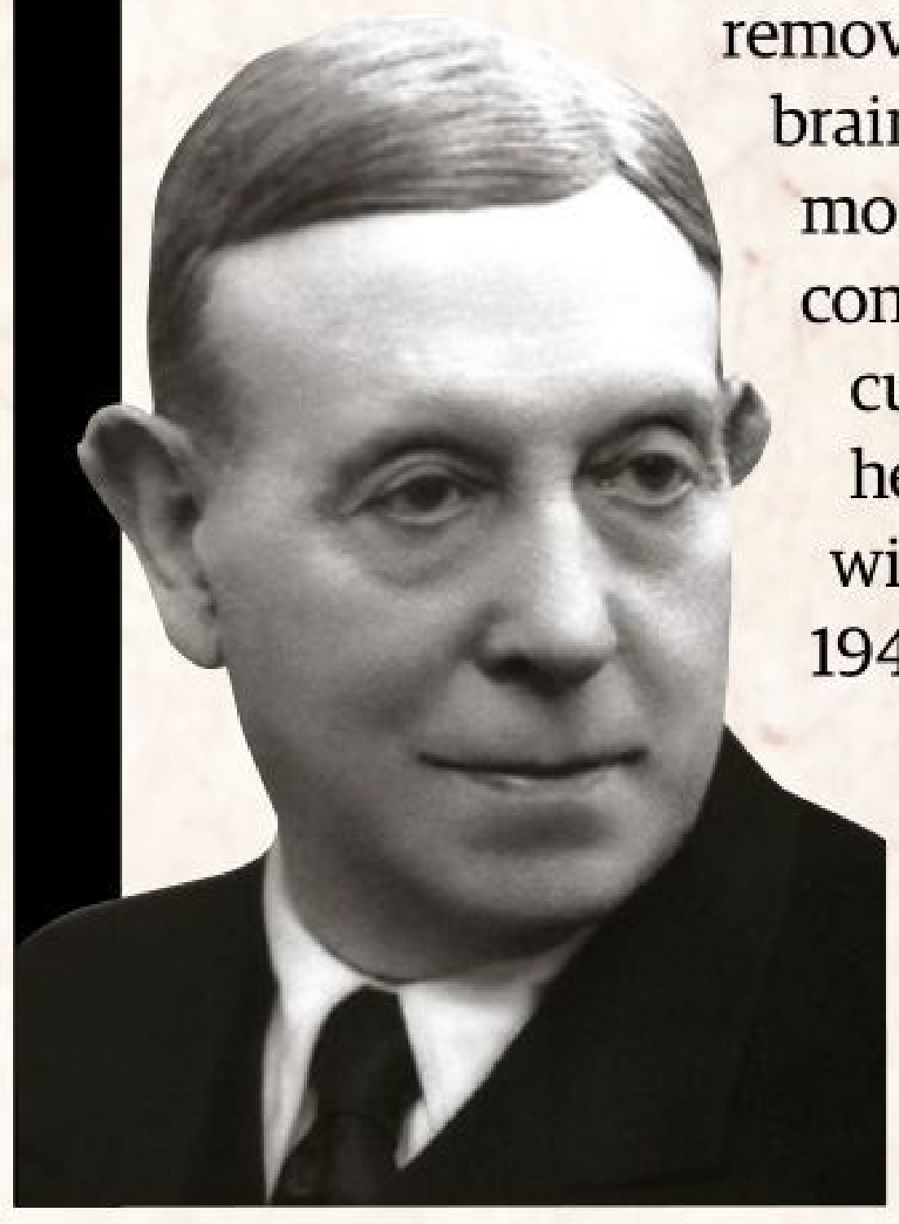
AUSTRALIAN 1929-2011

Carl Wood gave millions of women the hope of pregnancy, through his research into successful viable IVF treatment. He produced the first in-virtro fertilised egg, which was transplanted back into the mother. It was a momentous achievement and with further research he produced Australia's first test-tube baby in 1980. He experimented with freezing embryos so that they could be stored, steering the way for commercial IVF treatments that could be made available to everyone. While his treatments would draw controversy from critics who argued that he was playing God, his revolutionary methods meant that millions of couples were given the chance to have a family.

Antonio Egas Moniz

PORTUGUESE 1874-1955

Antonio Egas Moniz's expertise in neurology is as renowned as it is controversial. His work in studying the brain and the behaviours that stem from the frontal lobe has been highly significant in terms of its depth, but he also holds the ominous reputation as being the inventor of the modern lobotomy – a surgical procedure that has been condemned by medical professionals and laymen alike. During the Forties, the process of removing parts of the brain to stop psychotic mood swings was considered to be a cure for mental health disorders, winning Moniz the 1949 Nobel Prize for 'his discovery of the therapeutic value of [lobotomy] in certain psychoses'.



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HIPPOCRATES THE MAN BEHIND THE MYTH

His face (and beard) are recognised around the world despite the fact that he lived over 2,000 years ago. But how much of what we know about this archetypal doctor is actually true?

Hippocrates is known as the father of modern medicine. He is the man credited with revolutionising medicine in Ancient Greece – the one who separated it from philosophy and religion and made it a profession in its own right. But when it comes to the details of his life and achievements, it's very hard to determine fact from myth. Though around 60 medical writings – collectively known as the Hippocratic Corpus – have survived that were once attributed to him, we now know that in fact, more than a dozen authors were responsible for their creation. And though he is revered for setting ethical standards in medical practice – immortalised in the form of the oath that bears his name – there is much evidence to suggest that the oath actually predates him.

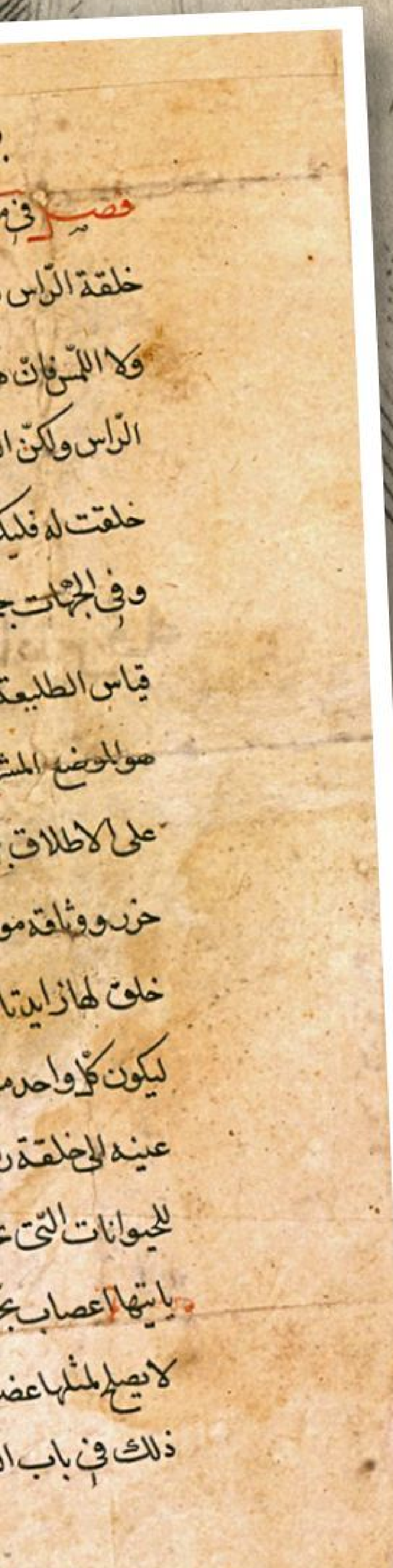
The Oath continued to be in use in the Byzantine Christian world, with its references to pagan deities removed

Despite the uncertainties, we do know for sure that Hippocrates was born around 490 BCE on the small island of Kos, just off the coast of modern-day Turkey. According to Aristotle, he was a "kind, dignified, old country doctor", and busts from ancient Greece depict him with a bushy beard and wrinkled forehead. During his long life, Hippocrates travelled extensively on the Greek mainland and in Thrace – now Bulgaria – sharing his knowledge and methods.

The 2nd-century-CE chronicler Soranus of Ephesus tells us that his father was a physician, and much of his early learning was through him. Hippocrates then went on to train at the local asklepieion – the Ancient Greek healing temple – where he was taught the art of dream therapy. Patients were encouraged to recall their dreams, which would then be interpreted by the priest-physicians in order to decide how their ailments should best be treated.

But despite his training at the asklepieion, Hippocrates is often credited with being the first person in the western world to attribute disease to natural causes, rather than considering it a punishment from the gods. For his outspoken criticism of religion-based medical practices, he received a 20-year prison sentence, during which time he wrote some of his

The Hippocratic Corpus – a collection of 60 works written by Hippocrates or perhaps his followers – was translated into Arabic and taught in the Muslim world



Very little is known about the details of Hippocrates' life most famous works. In these, he rightly asserted that environmental factors, diet and other living habits all play a part in a person's health.

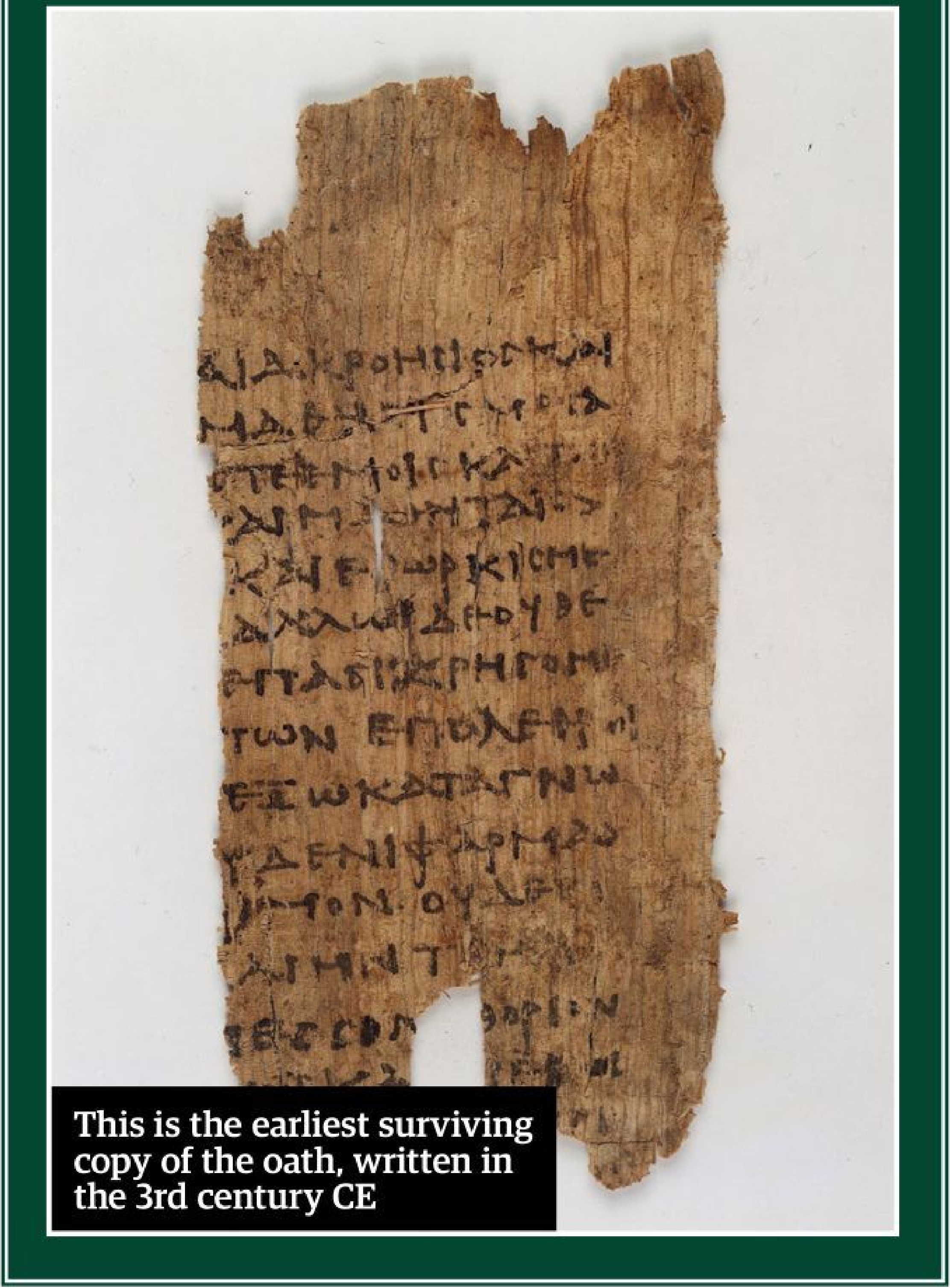
Before Hippocrates, physicians were not always taken seriously. In order to establish it as a respectable profession, Hippocrates advocated discipline and meticulous attention to detail. Physicians were to be well-kept, honest and serious. Hygiene and precision were of utmost importance, and he issued detailed instructions for "lighting, personnel, instruments, positioning of the patient, and techniques of bandaging and splinting" in the ancient doctor's surgery. He even recommended that physicians keep their fingernails to a specific length.

THE HIPPOCRATIC OATH

Among the most famous works in the Hippocratic Corpus is the Hippocratic Oath – a code of principles for the teachers of medicine and their pupils to follow. It is estimated to have been written between the 3rd and 5th centuries BCE, making it the earliest known expression of medical ethics in the Western world. It has been modified countless times over the years, and a version of it is still recited by medical graduates – albeit only for symbolic purposes.

In the oldest version available, dating from the 3rd century CE, a new physician was required to swear by a number of gods that they would "use treatment to help the sick according to [their] ability and judgment, but never with a view to injury and wrong-doing", and also that they would "never divulge" confidential information about their patients. Other promises included in the text were not to perform abortions and never to use a knife.

However, both of these practices are described elsewhere in the Corpus, suggesting that not all physicians followed the code. Most modern scholars now agree that Hippocrates is unlikely to have been the author, and it could possibly predate him.



This is the earliest surviving copy of the oath, written in the 3rd century CE

The Hippocratic 'school' that he founded, which was a way of thinking rather than a physical institution, set the modern standard of observation and documentation. It encouraged physicians to record their findings and methods as objectively as possible so that they could be used by other physicians in future. His observations extended to taking a family history and learning about his patients' living situation and healthcare regime – a practice that continues to this day.

One technique that he advocated was known as forecasting. It involved observing a patient over several days and noting down the progression of their symptoms. By doing this, they could make a natural history of an illness. In his text, *On Forecasting Diseases*, Hippocrates wrote: "I believe that it is an excellent thing for a physician to practice forecasting. He will carry out the treatment best if he knows beforehand from the present symptoms what will take place later."

The observation process was as follows: "First of all the doctor should look at the patient's face. If he looks his usual self this is a good sign. If not, however, the following are bad signs – sharp nose, hollow eyes, cold ears, dry skin on the forehead, strange face colour such as green, black, red or lead coloured. If the face is like this at the beginning of the illness, the doctor must ask the patient if he has lost sleep, or had diarrhoea, or not eaten."

Hippocrates and his followers were the first to describe many diseases and medical conditions, including clubbed fingers, a telltale sign of lung and heart disease. His methods for treating haemorrhoids are still used today, though with more sophisticated instruments. He was also the first to document chest surgery, and while his methods have been greatly improved upon, some have hardly changed – including the use of pipes to drain a chest wall abscess. His treatises explained how to set fractures and treat wounds, feed and comfort patients, and take care of the body to avoid illness. He also wrote about diseases relating specifically to women, childbirth and paediatrics.

Hippocrates took a holistic approach to medicine and many of his treatments simply prescribed a change in diet or increased physical or mental exercise. Massage and walks were considered necessary to restore health and ensure the well-being of the soul. He believed that a bad diet caused undigested residues that excreted vapours, which passed into the body and produced diseases. Emetics and laxatives were therefore two of the harder prescriptions handed out by Hippocrates. Diseases were allowed to run their natural course, with treatment restricted mainly to the use of herbal medicines. Liquid diets were recommended in the case of fevers and wounds, and he recognised that people who ate a plant-based diet had longer and generally healthier lives.

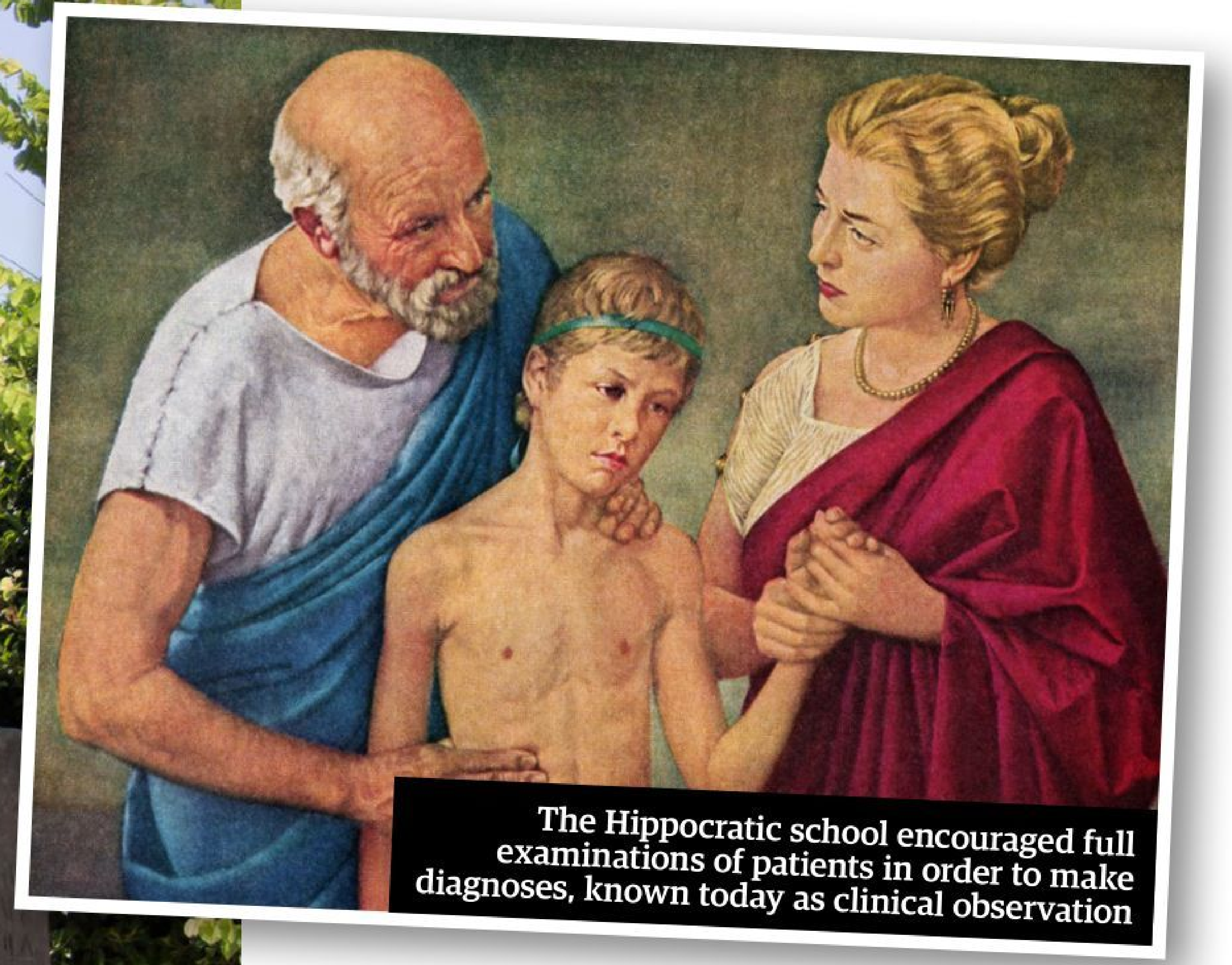
Hippocrates received his training at the healing temple of Kos, despite his later belief that religion and health were not related

Much of this was recorded in the Hippocratic Corpus, which we now know was written over a period of several centuries thanks to its many different styles and viewpoints. Some significant contradictions have even been found within it, and one historian has suggested that there were at least 19 different authors. It's possible that it may in fact be the remains of a 'library of Kos', where Hippocrates founded his school.

One of the theories described in great detail in the Corpus is humourism – the belief that health is affected by the balance of four bodily fluids: black bile, yellow bile, phlegm and blood. It's unlikely that these correspond to modern terminology; rather, it's possible that their roots lie in a blood sedimentation test in which Hippocrates observed that blood separates into four separate layers: clotted blood (black bile), unclotted erythrocytes

Hippocrates believed that a person's health was dependent on maintaining a balance of the four bodily fluids, known as humours

A statue immortalising the 'father of medicine' now stands on the island of Kos, where Hippocrates was born



The Hippocratic school encouraged full examinations of patients in order to make diagnoses, known today as clinical observation

(blood), white blood cells (phlegm) and a clear serum (yellow bile). Hippocrates believed that if a person was suffering from an excess or deficiency of one of these, their personality or physical health could be affected.

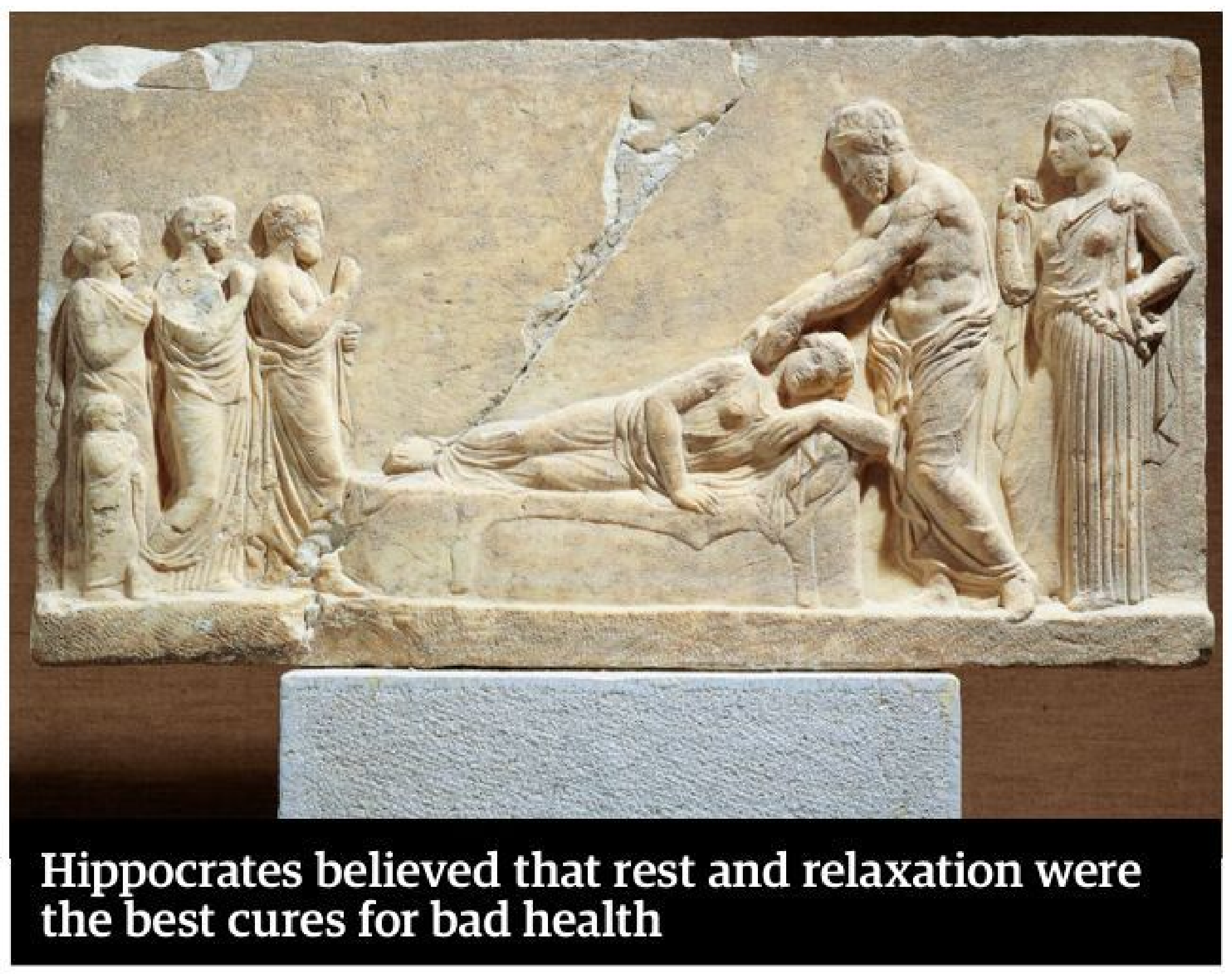
Humourism as a theory retained its popularity for centuries and came to the forefront of medicine once again in the 2nd century CE, thanks to the work of Galen, who was an avid promoter Hippocratic medicine. He built on Hippocrates' work to suggest that different foods caused the body to produce different humours. Warm foods, for example, tended to produce yellow bile, while cold foods produced phlegm. Seasons of the year, periods of life, geographic regions and occupations also influenced the levels of bile, blood and phlegm in the human body.

The theory was adopted by both the Romans and Islamic physicians, and it then became the most commonly held view of the human body in Europe. It was only in the 19th century that the myth of the four humours was completely dispelled, after German physician Rudolf Virchow published his theories of cellular pathology.

Hippocrates' reputation, and myths about his life began to grow in the Hellenistic period, about a century after his death. One such biography that encouraged the view of Hippocrates as a hero figure was *The Embassy*, which was included in the original Hippocratic collections in the Library of Alexandria. Now considered an overwhelmingly fictional work, it connected Hippocrates and his family with several key events in the history of Kos and Greece, in particular his role during an outbreak of the plague.

The Embassy relates that Hippocrates sent his students all over Greece to cure those affected, and when he was offered huge amounts of silver and gold by the barbarians to assist them also, he refused – saving Greece from invasion. Over the next four centuries, the tales in *The Embassy* were elaborated upon and used as the basis for further myths, including fictional accounts of interactions with Persian kings. Hippocrates' reputation as a great doctor grew as a result, eventually creating the traditional picture of him as the father of medicine.

It's believed that Hippocrates lived until a ripe old age, perhaps to around 85. After his death, advancements in medicine were stalled. So great were his accomplishments that few believed they could be improved upon, and in some ways medicine started moving backwards. Arguably, real progression was not made again until the Enlightenment period, after the fall in power of the Church. But the fact remains that so little is known about Hippocrates, some have even suggested that he never existed at all – rather, he is an amalgamation of many different physicians who lived over a number of centuries. The truth may be lost to history.



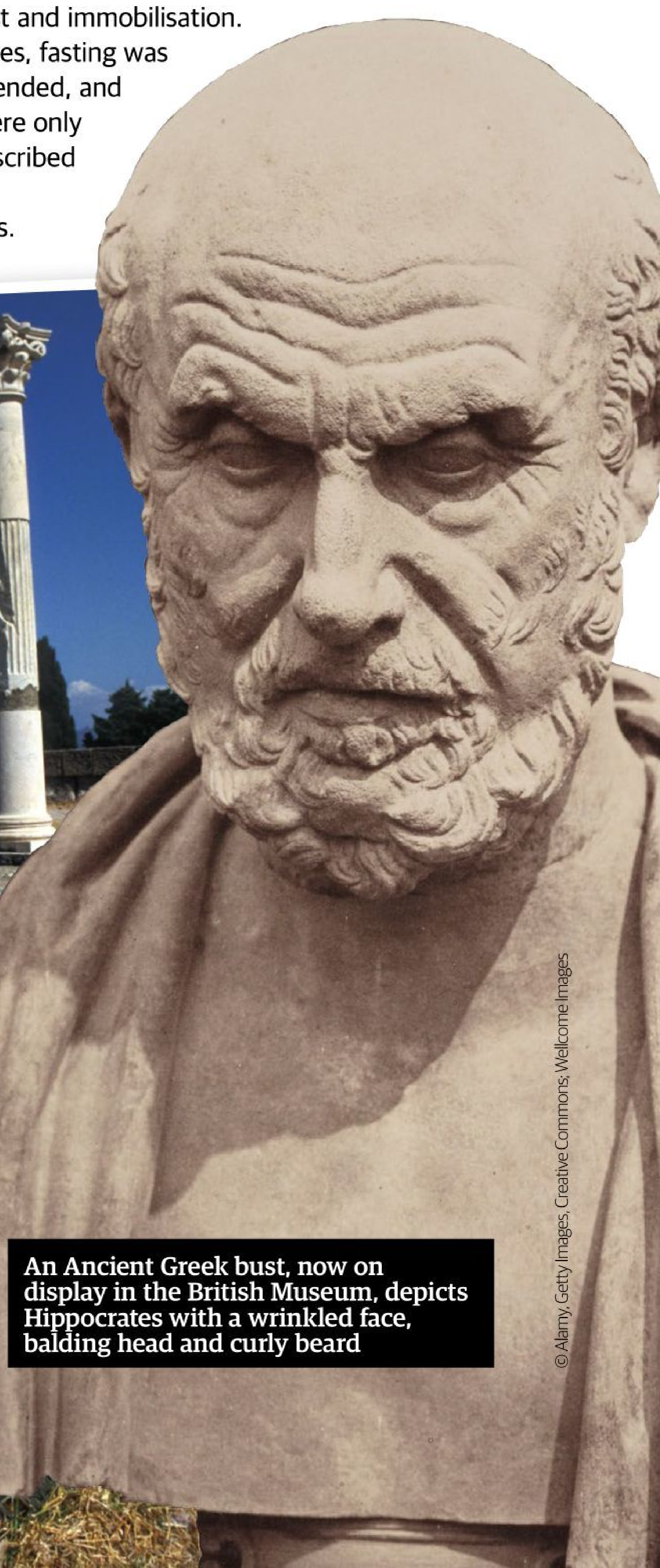
Hippocrates believed that rest and relaxation were the best cures for bad health

The concept of the Crisis

Hippocrates believed that all diseases would eventually reach a crisis point – a moment in time where the patient would either start improving, or succumb to the illness and die. If the former occurred, it was always possible that a relapse might follow, which would then be followed by another deciding crisis. These crises were supposed to occur at fixed times after the contraction of a disease, known as 'critical days'. If a crisis occurred much earlier or later than its expected critical day, a relapse was almost certain.

In Hippocrates' opinion, a patient's best hope was to let the illness run its course. Hippocrates believed in the healing power of nature, and taught that the body had the power to re-balance itself and fight the disease. Treatments were therefore gentle, with a focus rest and immobilisation. Sometimes, fasting was recommended, and drugs were only ever prescribed on rare occasions.

The remains of the asklepion at Kos, where Hippocrates learned his trade



An Ancient Greek bust, now on display in the British Museum, depicts Hippocrates with a wrinkled face, balding head and curly beard

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Galen and other physicians of the time had to resort to dissecting animals rather than humans

CLAUDIUS GALEN THE GREEK ROMAN DOCTOR

Physician to Roman emperors, one man made a huge difference to Roman medicine

Rome's greatest doctor wasn't born in the capital – instead, he hailed from a town by the name of Pergamum in Anatolia, situated in modern-day Turkey. Born around 130 CE, Claudius Galen made a name for himself in the ancient world through his knowledge and research of the human body and how it worked.

> The four humours theory led medicine in ancient Greece and Rome, and Galen was a strong supporter of it

Galen got off to a great start in life as his father, Nicon, was an architect who brought in a decent amount of money. As such, Galen's future was funded, and he was first educated as a philosopher, just like many of the great minds in the ancient Greek and Roman worlds. However, in 144 or 145, Nicon had a dream – Asclepius, the god of healing, had approached him and told Nicon that his son should study medicine. At the age of 16, Galen's path turned and he began his studies at the sanctuary of Asclepius with distinguished doctors in Pergamum.

When Nicon died around 149 CE, he left his son with a substantial inheritance, and Galen decided that it was time to leave his home town. He headed to Smyrna, Crete, Corinth and Cyprus to continue his studies, drinking in all the information he could before finally settling in Alexandria, the greatest medical centre of the ancient world and a hub of learning.

After a decade of study, Galen returned to Pergamum in 157 CE and promptly became the chief physician of the city's troop of gladiators that were maintained by the high priest of Asia. It was during his time here that he was able to study the human body through the gruesome injuries that the fighters obtained, and during his tenure only five gladiators died – a remarkable feat compared to the 60 who had died under the previous surgeon. However, he didn't stick around for long – he had too much talent and ambition to be stuck in a provincial city. In 162, he headed for the shining city of Rome.

The bustling metropolis of Rome was teeming with doctors wanting to be the best, and the medical scene was as competitive as it was corrupt. Galen managed to rise above the fray, making a name for himself through his public lectures and anatomical demonstrations. It was these activities that brought him into the spotlight and he came to the attention of the consul Flavius Boethius and then the emperor himself, Marcus

Aurelius. Of course, his vast fortune didn't exactly hinder him. He also made a name for himself by successfully treating rich and influential patients who other doctors had deemed incurable.

However, a plague threatened the capital in 166 CE and Galen decided to leave. He returned to Pergamum, although some have suggested that this was because of the envy of his colleagues. Even if that wasn't true, it was bound to become so when Marcus Aurelius and his co-emperor, Lucius Verus, asked him to return to Italy. They wanted him to come to their headquarters in Aquileia, near modern-day Trieste, where they were fighting against two barbarian tribes that were threatening the Danubian frontier.

Galen set off to join the emperors but plague forced them back down to the capital, where Galen met them and where he would remain until his death with the exception of a few trips to investigate scientific phenomena. With the emperors of Rome as his most illustrious clients, Galen's reputation skyrocketed. He must have amassed a small fortune, as he had a second home in Campania, a province to the south of Rome.

He wrote several books on anatomy and medicine, and he performed dissections on animals, as the law stated that no one could perform autopsies on people (although he did manage to dissect a couple of hanged criminals). He explored the anatomies of Barbary apes, pigs, sheep and goats, which led him to uncover more about how people worked and how to cure them. For instance, he discovered seven pairs of cranial nerves, was able to describe the valves of the heart, and observed the structural differences between arteries and veins.

But Galen didn't stop there. He realised that arteries carried blood, not air, around the body and he tied off the recurrent laryngeal nerve to prove that the brain controls the voice. He also established the functions of the spinal nerves through transections of spinal cords, and demonstrated the functions of the kidney and bladder. However, as he was unable to experiment on human corpses, some of his conclusions did turn out to be false. For example, he thought that a human uterus was like that of a dog and that blood was created in the liver.

> Galen became the most famous doctor in the Roman Empire and his theories dominated medicine for 1,500 years

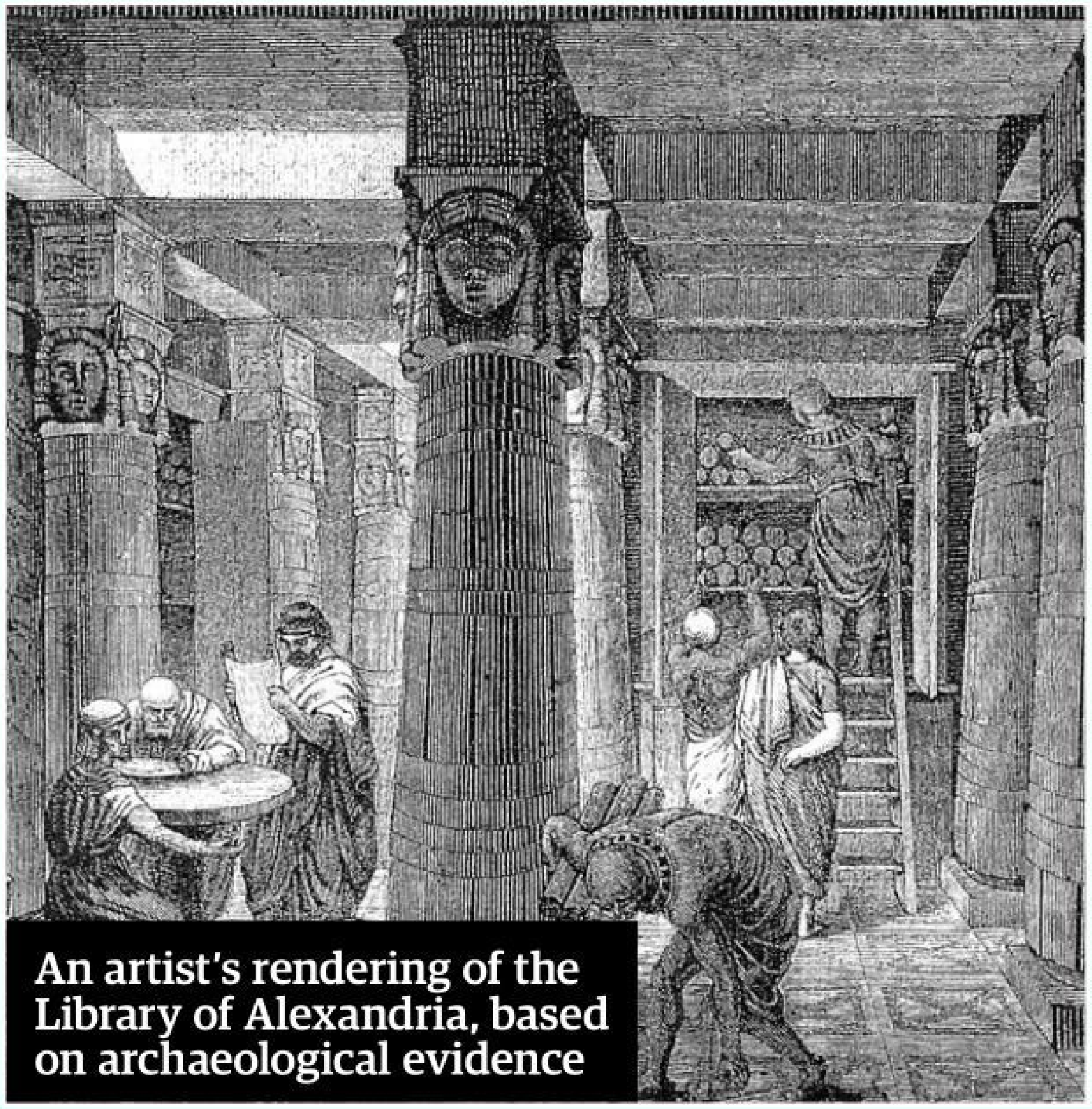
Marcus Aurelius was one of Galen's first imperial patients

THE HOME OF MEDICAL LEARNING

In the ancient world, Alexandria was the place to be to learn about medicine. An academic and cultural centre on the north coast of Egypt, it saw visitors from all over the Mediterranean and places further afield like modern-day Iraq.

Perhaps most importantly, the city was home to the infamous Library of Alexandria, which contained volumes from all over the known world. These were then translated into Greek so that more people could understand them, and the works influenced everything from history to science.

The number of books that were held in the library has been under contention pretty much since its building was completed by Ptolemy II, who reigned over Egypt from 285 to 246 BCE. Some historians suggest that there were 70,000 scrolls, while other estimates skyrocket their numbers to 500,000. The sad thing is that we'll never know, as the library was burnt down.

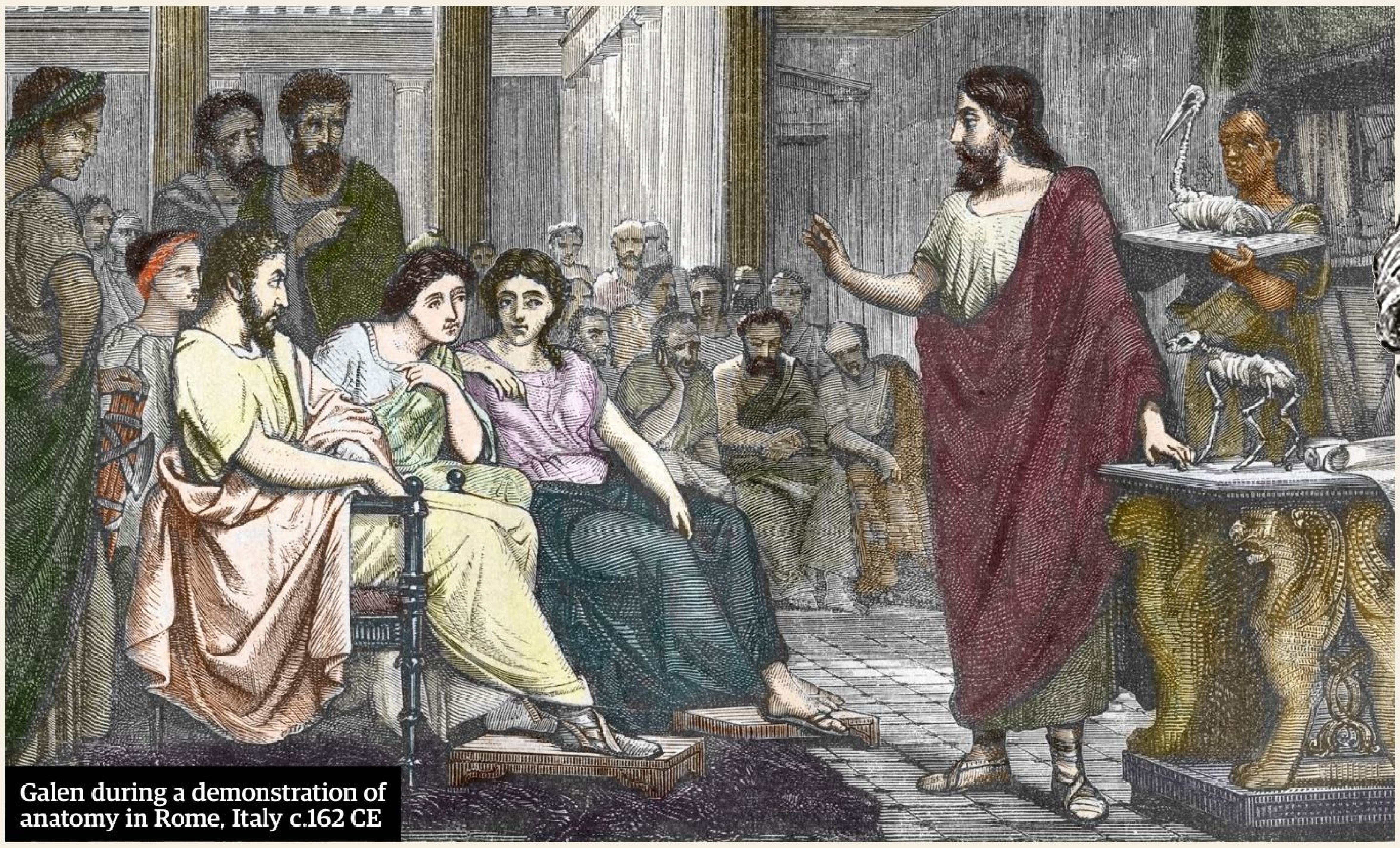


An artist's rendering of the Library of Alexandria, based on archaeological evidence

Like most doctors of the time, Galen was a strong proponent of the four humours theory, whereby disease related to the four humours of the body - yellow bile, black bile, blood and phlegm - which in turn related to the four elements: fire, earth, air and water respectively. He also revered Hippocrates as the fount of all medical knowledge, while using the works of Plato and Aristotle, but Galen's own influence on the medical field is hard to overstate.

Along with the discoveries mentioned above, the physician created the system of Galenic degrees - the first recognised attempt to precisely gauge the effects of medicines to treat maladies. He also wrote approximately 300 works over his lifetime, although only about 150 survive today. Part of the reason some don't survive is a fire that occurred in 191 CE, which burned down a storage warehouse where Galen was renting a space. Along with some of his written works, some hard-to-find medicinal ingredients also went up in flames, much to Galen's anguish.

Galen's books covered all sorts of areas in medicine, from physiology and anatomy through to hygiene, therapeutics and remedies. He discussed the four humours in his *On the Elements According*


Galen during a demonstration of anatomy in Rome, Italy c.162 CE

to Hippocrates, and explained his research of the pulse and its importance in treating patients in *Of the Use of the Pulse*. People could read about his cures in *On Remedies Easy to Prepare* and *On Antidotes*, while *Of the Bones* does exactly what it says on the tin.

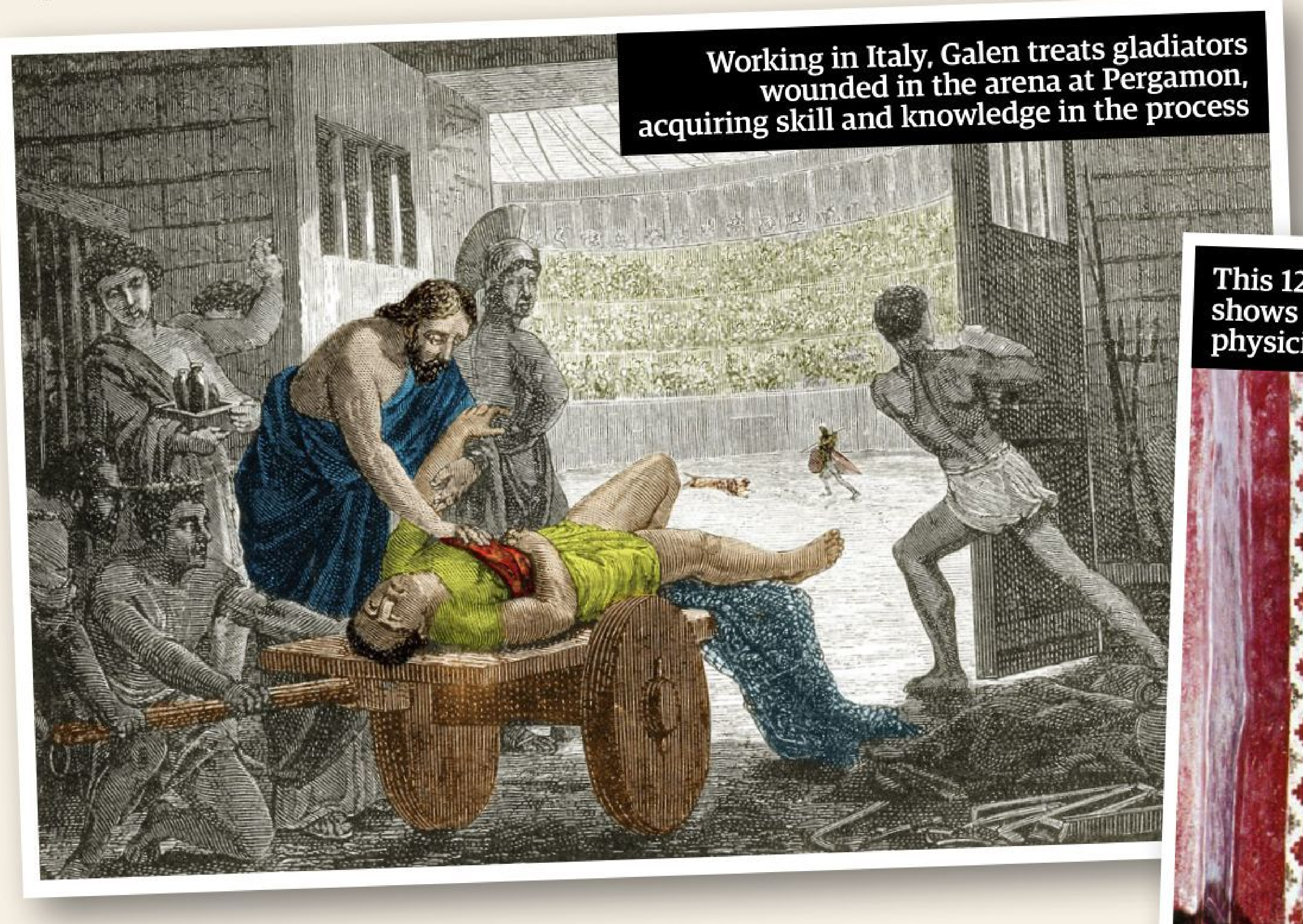
When Galen finally died in circa 216 CE, having served emperors Marcus Aurelius, Lucius Verus, Commodus and Septimius Severus, his work outlived him. Galen's theories went unchallenged for centuries, through the rest of the Roman Empire's days and into Medieval Europe and the Islamic world. In 500 CE, they were being taught in Alexandria, where Galen himself had studied, and the Byzantines couldn't get enough of citing him in their medical handbooks.

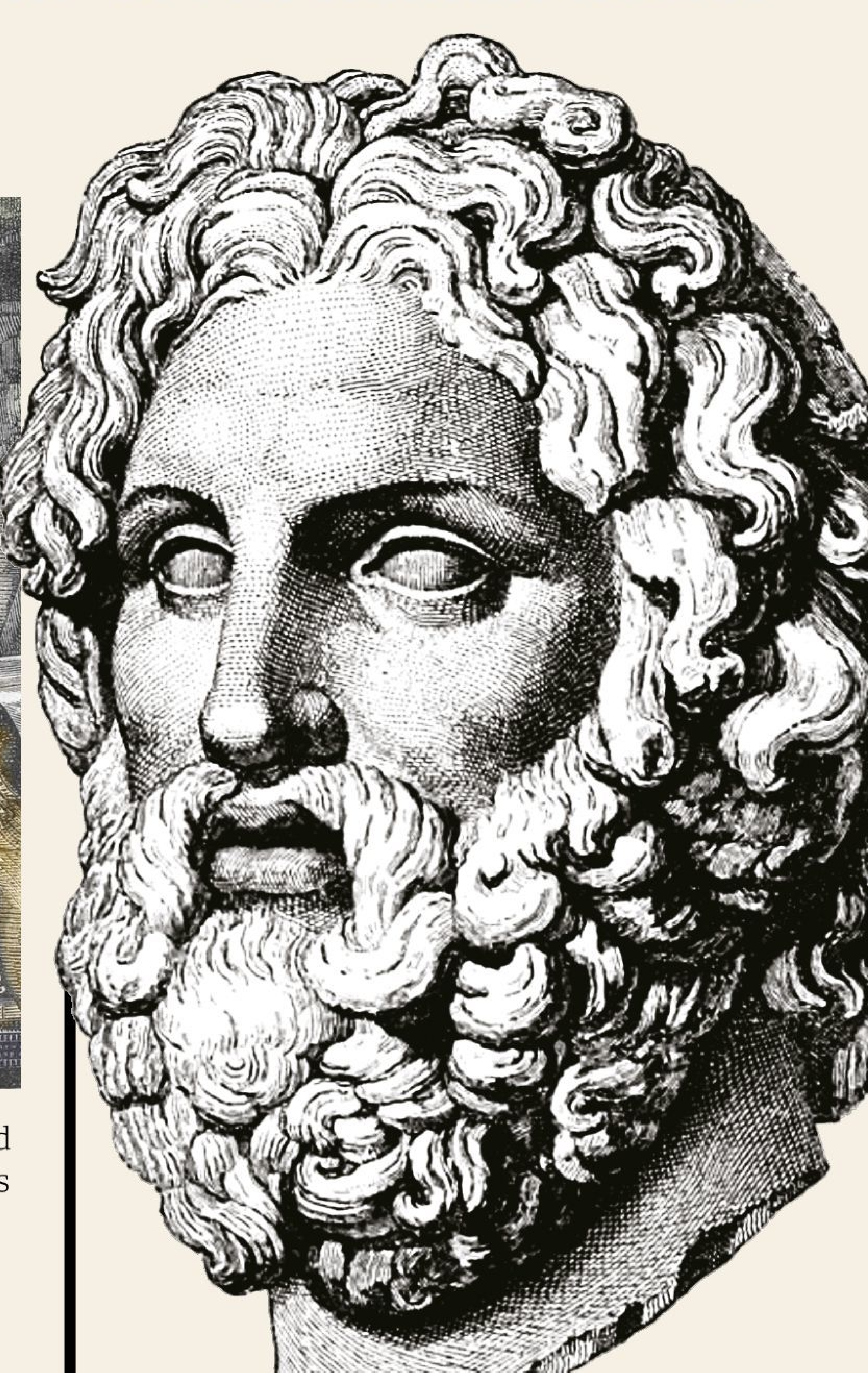
In the 9th century, Islamic scholars began translating Greek works into Arabic, and Galen's influence spread further into Asia. One such scholar was Hunayn ibn Ishāq, an Arab scholar based in Baghdad who translated Plato, Aristotle and Hippocrates so that their learnings could be used to advance medicine in the Middle East and beyond. Then, when these translations and the Greek originals were translated into Latin, Galen's learnings took hold in Europe. Italians in the 15th century were translating the Greek into Latin during the Renaissance and the texts were disseminated to places of learning throughout the continent.

However, this doesn't mean that Galen's work wasn't being challenged. Ibn al-Nafis, an Islamic physician and scholar, challenged Galen's views about the heart in the 13th century, while Andreas Vesalius showed that Galen's knowledge of the human anatomy was more based on animals than people in the 1500s.

Despite this, Galen's work and research was undoubtedly important. He had a successful track record for curing people in Rome, and even managed to become the Roman equivalent of a court-appointed physician for four emperors. His findings from dissecting bones and muscles have provided names that are still in use to this day, and he championed the cause of looking at individual cases of illnesses during the smallpox pandemic in the 160s CE to give detailed descriptions of the symptoms, so that more effective cures could be found.

Galen was perhaps the most acute and prolific medical writer in the ancient world - so much so that his theories outlived him by centuries, and his knowledge of the spinal cord wasn't fully appreciated until the 19th century. While his money and thus influence propelled him through his early years, perhaps the face of medicine today would be very different if he hadn't been researching and treating his patients nearly 2,000 years ago in Ancient Rome.


Working in Italy, Galen treats gladiators wounded in the arena at Pergamon, acquiring skill and knowledge in the process

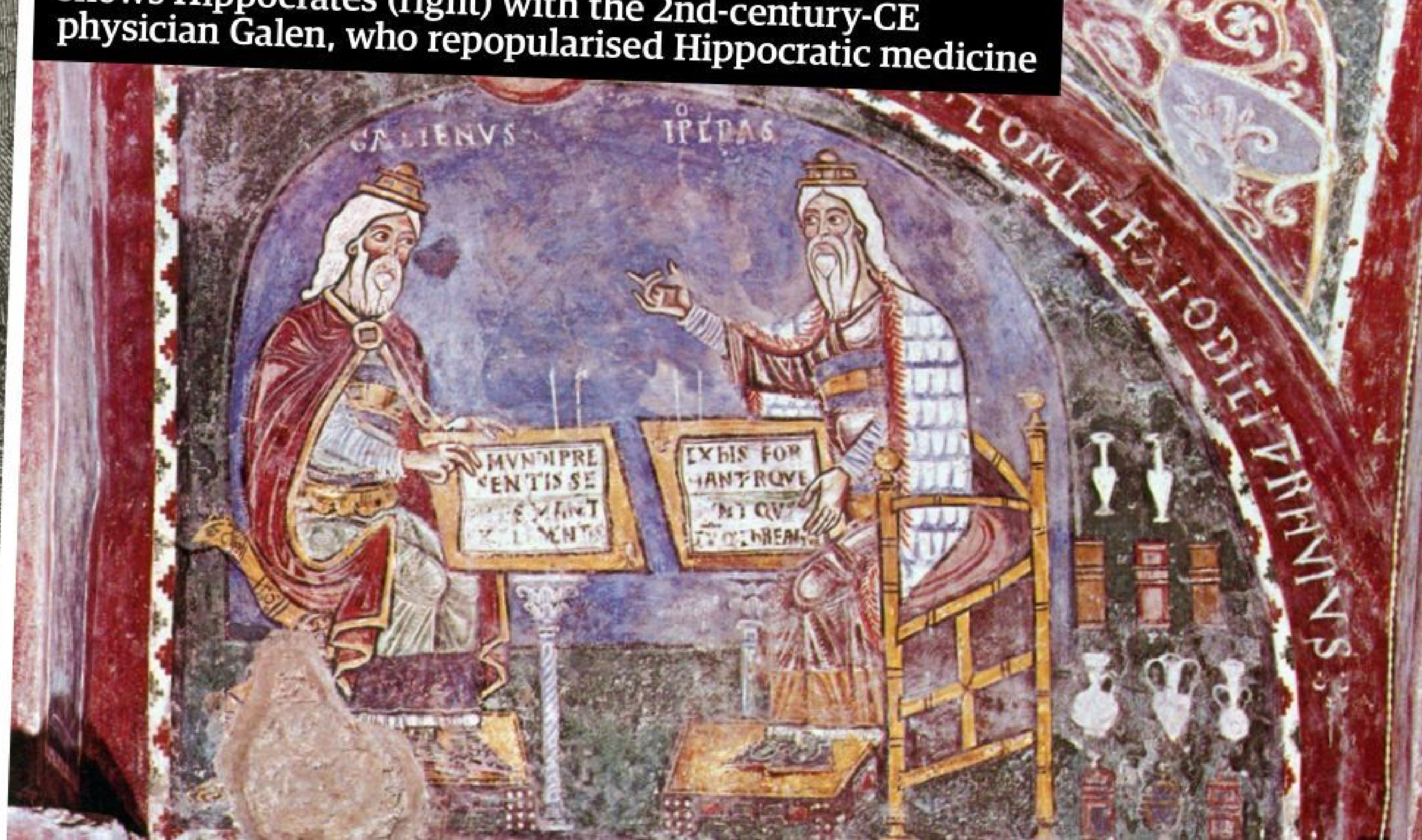

Asclepius was mentioned in the original Hippocratic Oath

The god of healing

The son of Apollo, Asclepius was the Greek god of medicine in the Hellenistic pantheon. His father had supposedly given him the gift of healing, and he was able to use plants and herbs in his cures.

There were many sanctuaries dedicated to Asclepius across the Greek world, the most important of which was at Epidaurus. This particular site was visited by those who wished to be cured of their ailments by the god or his priests. They would also stay there overnight to await dreams where Asclepius would give them the remedy.

Other sanctuaries were located in Athens and on the island of Kos, which had a medical school from the 5th century BCE. But it was the sanctuary at Pergamum that Galen studied at. This one was opened some time in the 4th century BCE, and there it remained for years to come. Under the Romans the site flourished, reaching a peak in the 2nd century CE and making it second only to the sanctuary at Epidaurus. Even when Christianity swept through the empire, it was still used as a medical and healing centre.


This 12th-century mural on display in Anagni, Italy, shows Hippocrates (right) with the 2nd-century-CE physician Galen, who repopularised Hippocratic medicine

© Alamy, Getty Images

LEONARDO DA VINCI ARTIST OF ANATOMY

How the Renaissance polymath, Leonardo da Vinci, left a lasting legacy on the medical world with his fascination for the human body

Almost immediately, the name Leonardo da Vinci conjures up a vision of the artist and some of his most iconic paintings, such as the *Mona Lisa* and *The Last Supper*. He was, undoubtedly, one of the greatest painters to have ever lived. Yet he was also an extremely talented anatomist, and his groundbreaking observations of the human body have helped to shape medical science as we know it today - even though they took centuries to actually come to light.

For a man whose intellectual work has captivated the world since his death, we know relatively little about his early life. He was born in 1452 in the small town of Vinci, the illegitimate son of a wealthy notary, Piero da Vinci and a peasant woman, Caterina. He lived with his mother until he was five years old, before he moved to live with his father.

Aged 14, da Vinci became the apprentice of Andrea del Verrocchio, an acclaimed artist, who taught him a variety of different skills. It was thanks to Verrocchio that da Vinci first became interested in anatomy, as the mentor encouraged his students to study the subject. This enabled them to develop their observational skills to paint as accurately as possible - something that can clearly be seen in da Vinci's artwork and drawings.

As an artist, da Vinci became a master of topographic anatomy, detailing the body's muscles and tendons

However, it was not until he began working for the duke of Milan, Ludovico Sforza, that da Vinci really began to pursue his interest in human anatomy. In a new notebook, which he dated 2 April 1489, he started his *Book entitled On the Human Figure*, and created a series of anatomical drawings of the human skull. Today, this notebook is known as *Anatomical Manuscript B*. But soon enough, da Vinci became frustrated with the lack of access he had to actually observe a real human corpse. Plagued with a short attention span, he quickly moved on to other matters, a pattern that would repeat itself frequently throughout his lifetime.

Regardless, da Vinci never forgot his fascination with the human body, and he developed a plan to create a treatise on the human anatomy. Between 1507 and 1508, almost 20 years since he had first

Da Vinci was a talented anatomist who dedicated much of his time to understanding the human body

> "Da Vinci needed a strong stomach to survive his pursuit for knowledge"

put ink to paper to create those intricate drawings of the skull, da Vinci renewed his project. In Florence, he met a man in a hospital who was 100 years old. The man had told him that, aside from feeling weak from his old age, he had no other issues with his body.

Da Vinci watched as the man slowly passed away, before deciding to dissect the dead body. Now this is certainly not a normal instinct to have. But, in his own words, da Vinci wanted "to see the cause of so sweet a death". From his observations, he gave what is the earliest known description of cirrhosis of the liver. He even drew the appendix, which again was another first for the world.

DA VINCI'S GLASS HEART

Out of all of the different areas of the human anatomy that da Vinci observed, it is his work on the heart that is arguably the most famous. His fixation with blood flow, and how it caused the arterial valves to open and close, inspired him to create his own model.

He started by pouring wax into the gate of an ox's heart before waiting for it to completely set. da Vinci then used the wax replica as a template to create his own version of the heart out of glass, which would enable him to see through it clearly. Next, he pumped water and grass seeds through the glass heart, noting that the widening at the base of the aorta caused vortices that made the grass seeds swirl around, which helped the aortic valve to close.

Da Vinci also managed to observe the heart's rotational movement, another fact that was unknown at the time. As extraordinary as the glass heart was, what da Vinci had seen would not be repeated again until the 20th century. However, he never worked out that the heart was responsible for pumping blood around the body – William Harvey went on to discover this in 1628.

One of da Vinci's many sketches that focuses on the intricate details of the heart

Yet the most fascinating observation that da Vinci had made concerned the man's heart. From his examination, he gave the first known description of coronary artery disease, suggesting that if the arteries were to 'fur up' then they could be a possible health risk. Once again, da Vinci had come to a conclusion that had never been made before in medicine, demonstrating just how perceptive he actually was.

This, coupled with later dissections he performed on the hearts from an ox and a pig, provided da Vinci with an understanding of the heart that went beyond the medical thinking of his time. He figured out currents in the blood flow, that the heart was not responsible for warming the blood in the body, and that it was a muscle, a fact that had never been grasped before. He also realised that the heart had four chambers, and the pulse in the wrist was connected to the contraction of the left ventricle.

However, after all this work the genius was far from finished. Hoping to perform more human dissections, da Vinci received permission to use the human corpses at hospitals in Florence, Milan and Rome. This was not a usual practice, but da Vinci's reputation allowed him to make such requests. As there was no way to preserve the bodies during the 16th century, they would have been in a state of decay with a strong and pungent smell – da Vinci needed a strong stomach to survive his pursuit for knowledge.

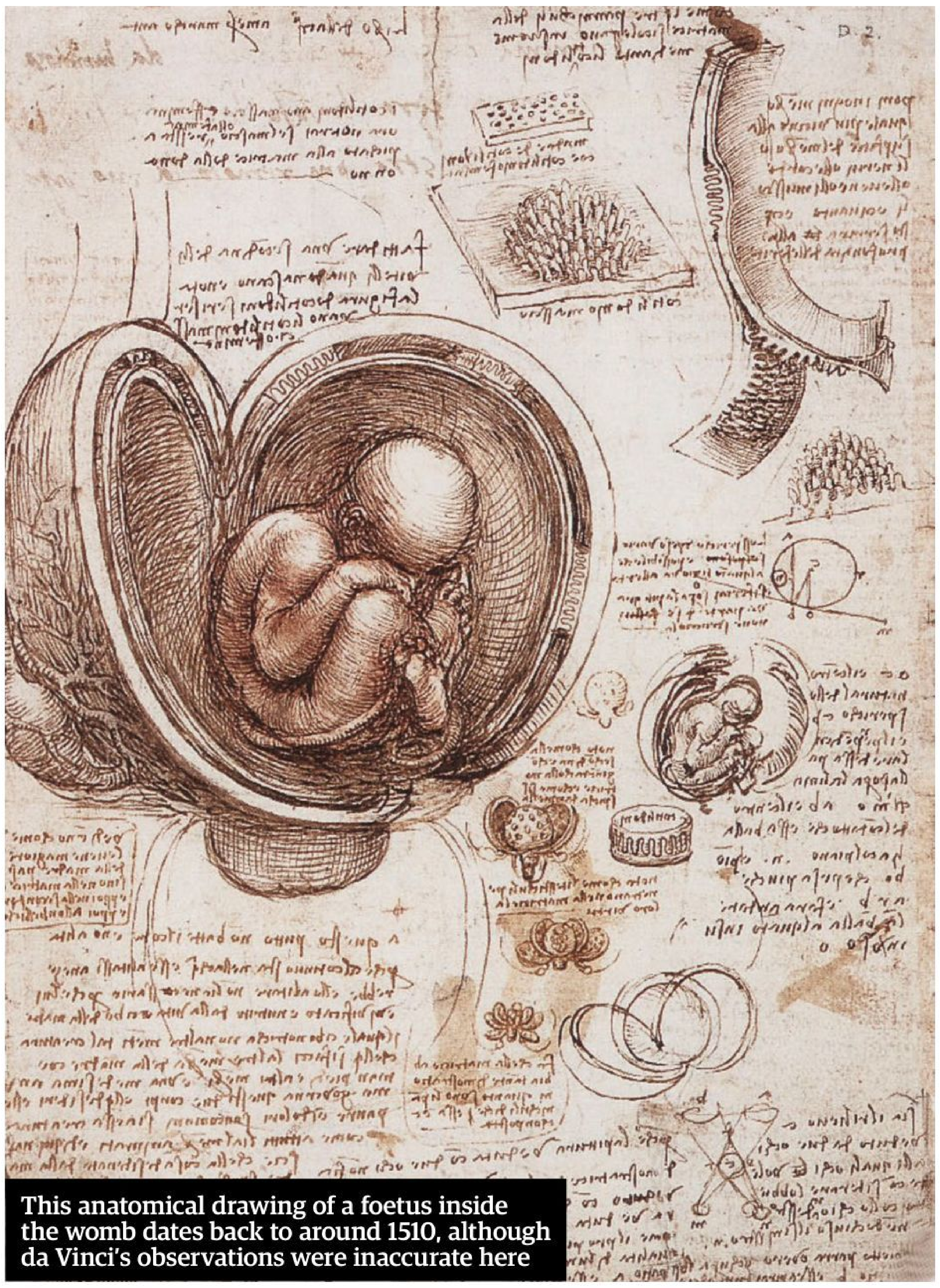
In the winter between 1510 and 1511, around two years after his dissection of the 100-year-old man, da Vinci created a series of 18 mostly double-sided sheets of paper with over 240 anatomical drawings accompanied with around 13,000 words of notes. Among them were his numerous detailed sketches that illustrated many of the different muscles and bones in the human body. Collectively, these pages are known today as *Anatomical Manuscript A*, currently held by the Royal Collection in London.

They were supposed to form part of the ambitious treatise that he had been in the process of developing alongside a doctor, Marcantonio della Torre, who was actually a young professor of anatomy. Unfortunately, their plans to publish screeched to a halt when della Torre suddenly died from the plague in 1511, ending da Vinci's plan and leaving their project incomplete.

> Da Vinci dissected at least 30 corpses so that he could get a better understanding of the human anatomy

Although a setback for da Vinci, he continued to perform dissections, and by 1513, he had done more than 30 of them on both healthy and diseased human corpses. During this time, he continued to create his anatomical drawings of the different body parts and organs, such as the arms, the muscles, vessels and the brain – just to name a few of them. One of his most famous studies was of the spine, for which he became the first person to accurately depict the curved shape of the backbone.

Of course, there is no denying that da Vinci's uncanny anatomy skills were genius, but he was not always correct with his observations. For example, his drawings for the female reproductive organs were incorrect, and were closer to those



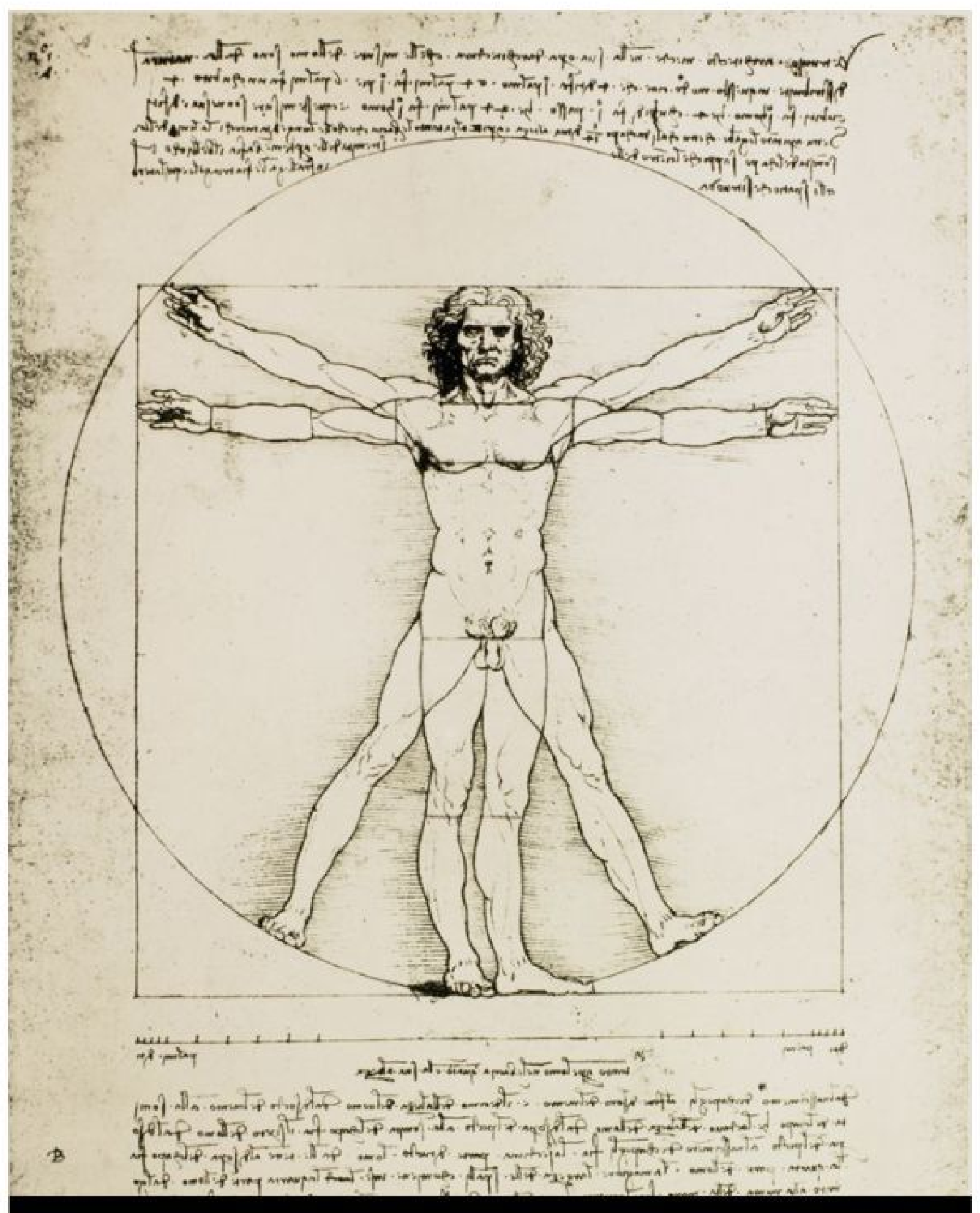
This anatomical drawing of a foetus inside the womb dates back to around 1510, although da Vinci's observations were inaccurate here

Da Vinci's work inspired the creation of the da Vinci surgical robot, which is used in surgeries around the world

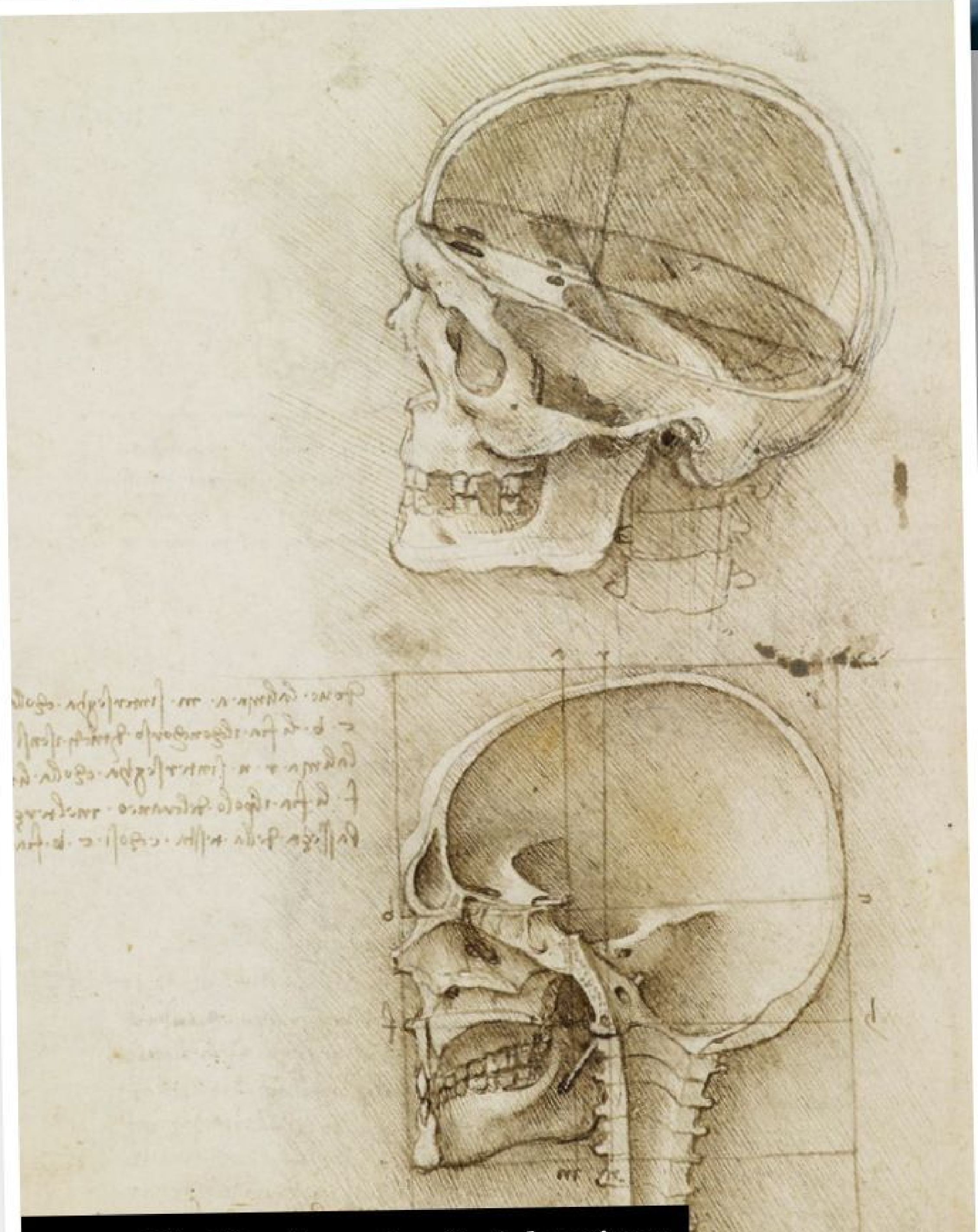
The Vitruvian Man

Drawn around the year 1490, da Vinci was influenced by the writings of the Roman architect Vitruvius, to create the iconic sketch of the *Vitruvian Man*. He stated his belief that "man is the model of the world", and based his drawing on the ideal proportions for the human body, in correlation with the geometry work of Vitruvius. Each separate part of the *Vitruvian Man* is a simple fraction of his whole body, for example his outstretched arms are as wide as the body is tall.

Da Vinci's iconic sketch is a testament to his understanding of the proportions of the human body, as well as further evidence of his ability to create accurate anatomical drawings. It also points to his commitment to produce work that was scientifically precise, while also trying to relate man to nature – summing up his belief that the human body was an analogy for the workings of the universe.



Da Vinci's *Vitruvian Man* emphasises just how well the anatomist really understood the human body



One of da Vinci's anatomical drawings of the human skull from 1489, found in *Anatomical Manuscript B*

belonging to animals rather than humans. Interestingly, this is most likely why his famous illustration of a foetus inside the womb was actually based on a dissection he performed on a pregnant cow. Having said this, it should be noted that while da Vinci had gained access to human corpses, it was far harder to come across a female one, which would have limited his ability to examine the female body properly.

As da Vinci continued with his study of the human body, his anatomical drawings started to tell a different story. He had originally placed a lot of emphasis on creating exquisite illustrations, but they eventually became less artistic as his interest in physiology increased. Now, he was more concerned with the function of the inner workings of the body than the structure of it, right down to how emotions affected the human body. In particular, he focused on the muscles in the body and how they moved, as well the bones - he dedicated at least ten studies to the forearm alone. As da Vinci himself stated, he believed that "movement is the cause of all life."

In fact, he applied his understanding of the mechanics of movement to create his own design for a robot. Indeed, da Vinci's robot, his anatomical drawings and his mechanical knowledge inspired scientists to develop the da Vinci surgical system, a robot used to perform invasive and keyhole surgery. Introduced in 1999, the da Vinci system has treated more than three million patients worldwide, ranging from heart surgery and hysterectomies to joint replacements. It also has numerous advantages, including shortened recovery time as well as minimising the size of the incision needed.

Da Vinci also used his interest in robotics and understanding of the human anatomy to design his own artificial limbs. Although technology was not advanced enough for him to pursue these inventions, da Vinci knew that it was entirely possible to create them. Five centuries later, and his knowledge and designs for his ideas have helped to influence the development of artificial limbs and even artificial organs.

Many of da Vinci's sketches and ideas lead to the creation of medical methods that are still used today

In 1517, da Vinci returned to his plans to publish his extensive treatise on the human body, but sadly he passed away two years later, before he had the chance to do so. Consequently, many of his drawings remained unseen for around 250 years after his death, although his beneficiary, Francesco Melzi, had attempted to organise them.

If da Vinci's work had been discovered sooner, it could have revolutionised medicine and the world's understanding of human anatomy. In 2013, an exhibition by the Royal Collection Trust displayed 30 of his anatomical drawings alongside CT and MRI scans that show just how accurate he really was – and that his work is still being proven right after 500 years. Da Vinci's work might have remained hidden from the outside world both during and after his lifetime, but clearly his influence on medicine and his lasting legacy still exists today.

© Getty Images

It has been said that Paré was worth 10,000 men on the battlefield, as soldiers knew their chances of survival were greater with him present

AMBROISE PARÉ FATHER OF MODERN SURGERY

A pioneer of surgical art, Ambroise Paré's techniques in dealing with cauterised wounds during wartime France were both ground-breaking and lifesaving

Born in the early years of the Renaissance in the northwestern French town of Bourg-Hersent in 1510, Ambroise Paré's youth was a time of great change for the country. France, a much smaller province than it is by today's standards, had barely recovered from a severe demographic decrease. During its mid-14th-century visit, the Black Death had killed approximately one-third of the country's population. This, followed by the Hundred Years' War, had slowed the repopulation and development of the country, and by the early 16th century, when Paré was a child, France was eagerly awaiting the colourful period of change and progression.

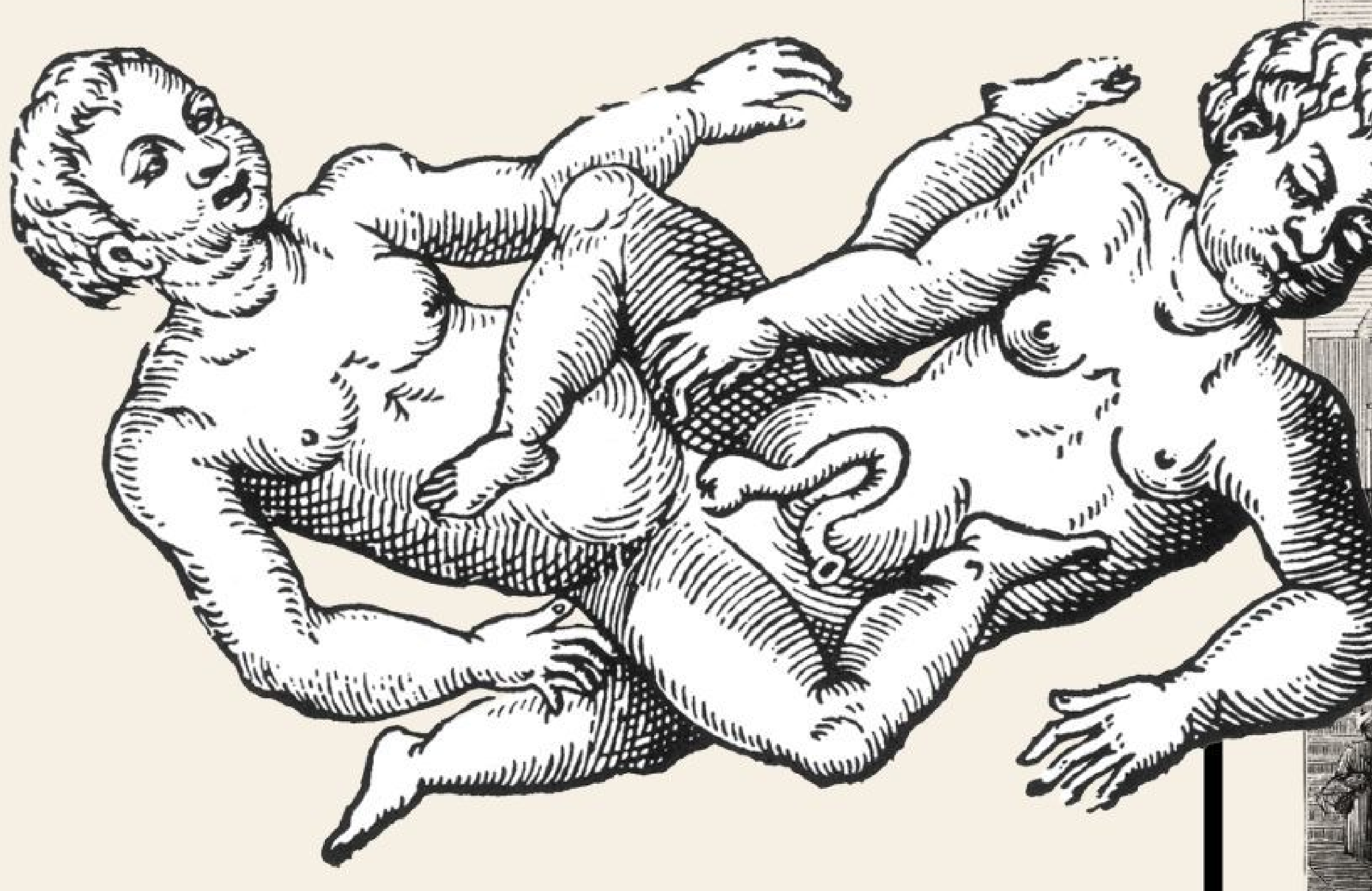
Paré grew up in and among a family of barber-surgeons; an occupation that had been born in the Middle Ages, the 'professional' duties of (often) illiterate razor-wielding coiffeurs ranged from hair cuts to tooth extraction and sometimes amputations without any formal medical training. University-trained physicians regarded the barber-surgeon trade as inferior, as most formally trained physicians were clergymen, and due to the stranglehold the Catholic Church had over medical practices, which for various reasons forbade clergymen from touching bodily fluids. Surgery was therefore performed by untrained practitioners. Barber-surgeons often trained through extensive apprenticeships and continued their studies in public hospitals, which primarily focused on palliative care, compared to hospitals today where the sick are treated effectively.

Paré was a surgeon to four French kings throughout his life, including King Henry II of France

Growing up, Paré's education was substandard and unremarkable. He studied barber-surgery as an apprentice of his older brother, and between the ages of 22 and 25, served under the surgeons of the Hôtel-Dieu in Paris – a renowned centre for medical training, and Paris' longest-working hospital today. Here, Paré was a clinical assistant studying anatomy and surgery, an experience of great importance to his future career.

For more than a millennium, since the 2nd century, the writings of Greek physician Claudius Galen heavily influenced medicine. Come the time

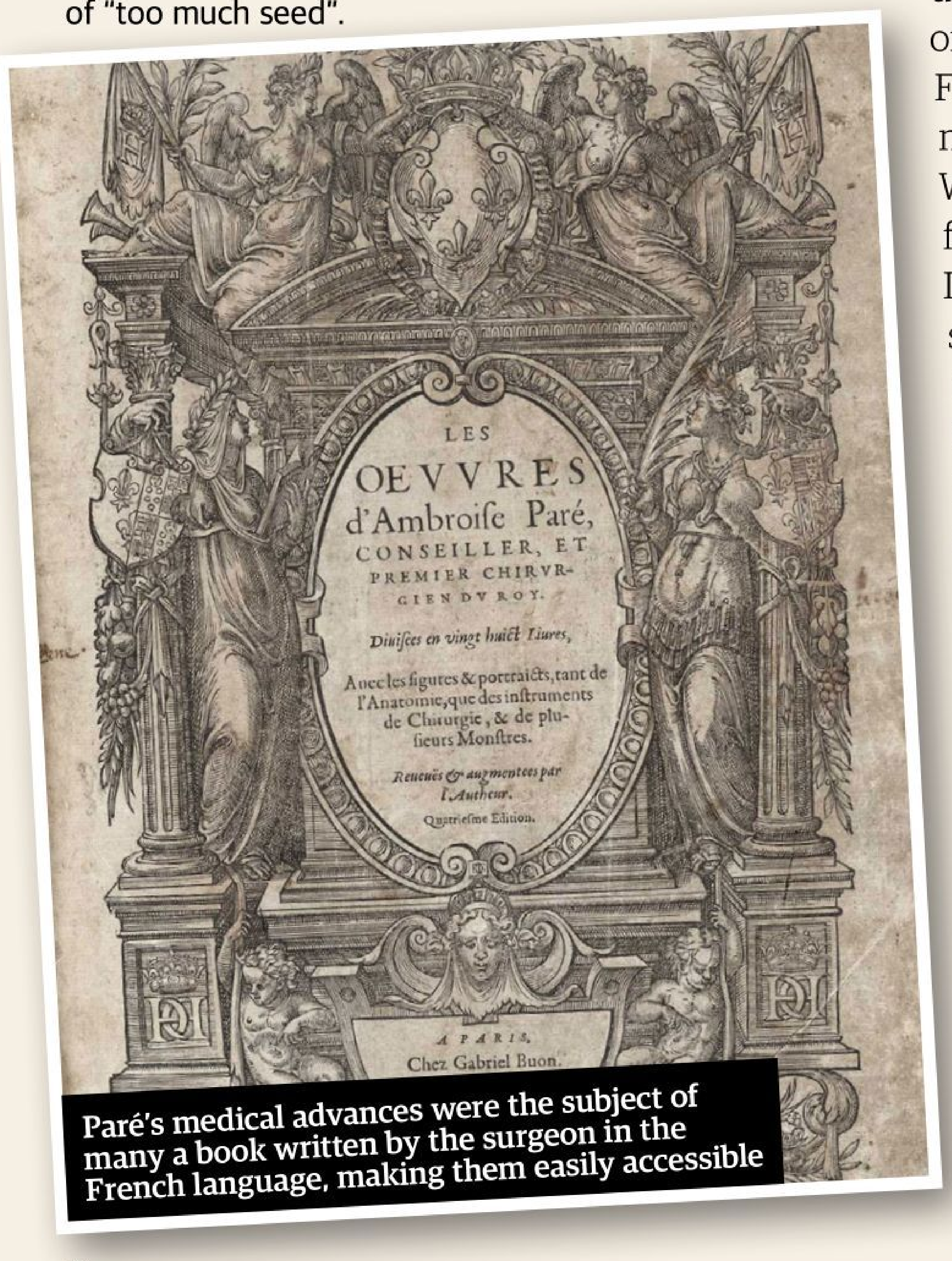
As a young trainee, Paré attended the renowned Hôtel-Dieu in Paris, where he studied as a clinical assistant



Paré's pregnancy marvels

At the age of 61, Paré's 'expertise' turned to obstetrics, and a set of his works focused primarily on birth defects. In his book *Monsters and Marvels*, Paré listed reasons as to why birth defects occur. While many of them were somewhat bizarre, Paré believed any one of the following to be attributable to the disability: the glory of God; the wrath of God; too much seed; too little seed; corrupt seed; mingling of seed; indecent posture by the expectant mother; a narrow womb; a blow to the mother; demons and devils; and finally, the mother's imagination.

His book goes on to delineate 'conditions' that may arise as a result of these factors, from Siamese twins to babies born with a horse's head and human body. Paré proceeds to attribute, without medical evidence, certain conditions to actions performed during pregnancy. For example, he attributes a baby with two heads as an outcome of "too much seed".



LES
OEVVRES
d'Ambroiſe Paré,
CONSEILLER, ET
PREMIER CHIRVR-
GIEN DV ROY.

Diuiſees en vingt huict Liures,

Auec les figures & portraicts, tant de
l'Anatomie, que des inſtruments
de Chirurgie, & de plu-
ſieurs Monſtres.

Reueuës & augmentees par
l'Autheur.

Quatrieſme Edition.

A PARIS,
Chez Gabriel Buon.

Paré's medical advances were the subject of many a book written by the surgeon in the French language, making them easily accessible

of the 16th century, doctors, surgeons and indeed the general population still strictly abided by Galen's teachings and empirical knowledge, which had been the subject of many a book written by the physicist on the treatment of diseases and the anatomy of the human body. However, despite Galen's insistence that observation was a necessary part of medical education, this was largely ignored by the masses. Galen's teachings, closely followed by Hippocratic ideologies, made up the wealth of 'knowledge' doctors had on how to treat patients. In early 1536, unable to afford the licensure exams, which would enable Paré to carry on practising as a medical professional, he left the Parisian training hospital. It's unknown whether the outbreak of a war between Italy and France influenced his next move, but in March the Italian War commenced, the result of a feud between King Francis I and Italy's King Charles V. The battle signified another great change in the landscape of France, as well as Paré's profession as he joined King Francis I's campaign to Italy acting under his sponsor, René de Montjean, a colonel general of the infantry.

In his lifetime, Paré served on many campaigns as a military medic, but on his first mission, in the northern hills of Italy, came the turning point of modern medicine. With new weapons and gunpowder making their debut on the battlefield, the war brought to the practice of dealing with wounds inflicted by gunpowder-driven projectiles to the forefront of surgical medicine. Prior to the 16th century, medics had limited knowledge of how to effectively treat such wounds, and for those seriously injured, few options were available. A significant event in Paré's career was when a soldier approached him for advice. At his side were two men who had been burned by gunpowder. The soldier asked Paré if anything could be done to help them. Examining their wounds, the surgeon shook his head - the men were injured beyond help. The soldier then calmly took his dagger and slashed their throats, killing them on the spot. Horrified, Paré screamed that the soldier was "a villain", to which the soldier simply replied: "Were I in such a situation, I would only pray to God for someone to do the same for me."

“On his first mission, in the northern hills of Italy, came the turning point”

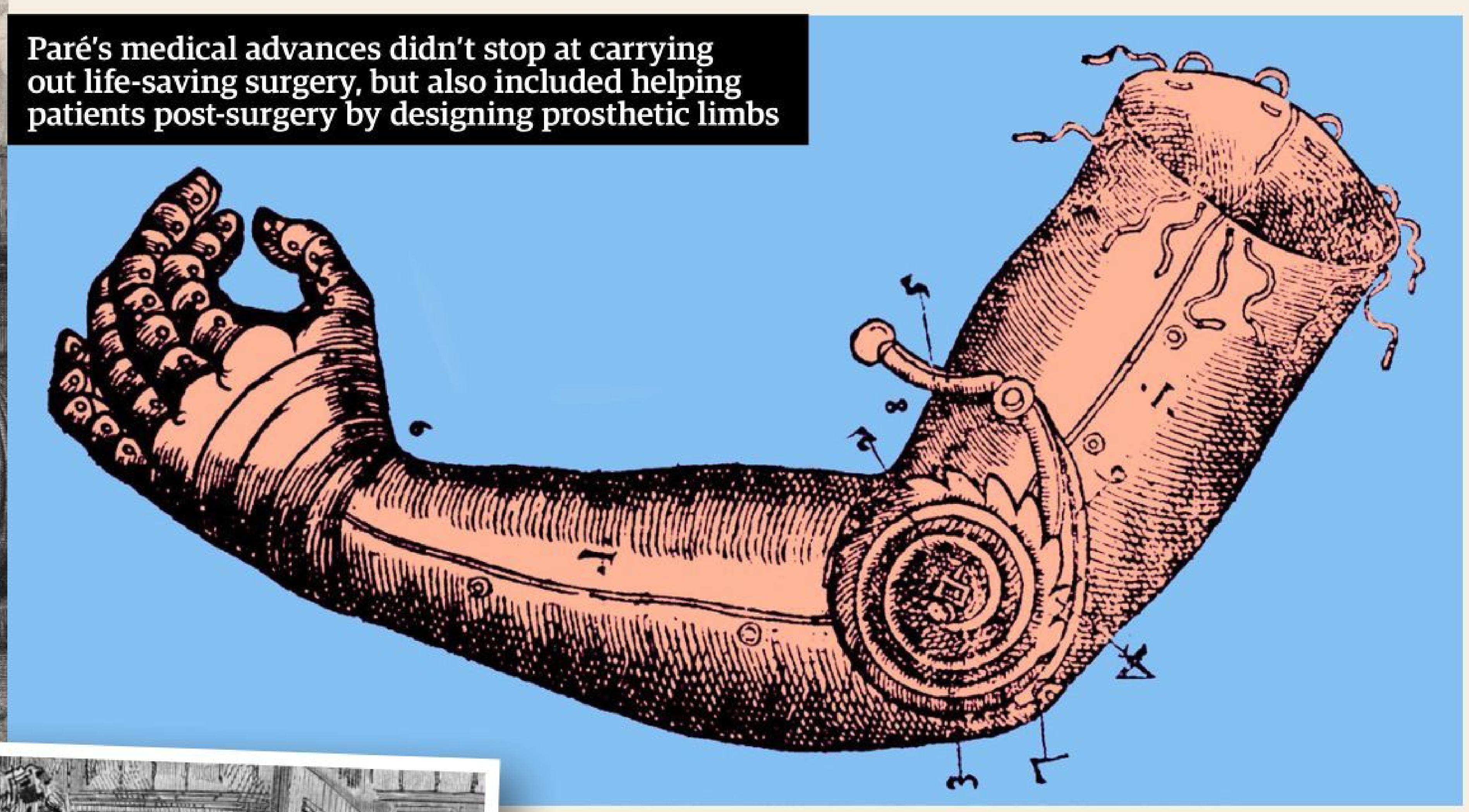
Could these words have been a starting point for what was about to come for Paré? Could this have influenced what would be his surgical mantra, which centred on delivering the injured from acute suffering and misery?

In his lifetime, Paré served as a battlefield medic in no fewer than 17 campaigns

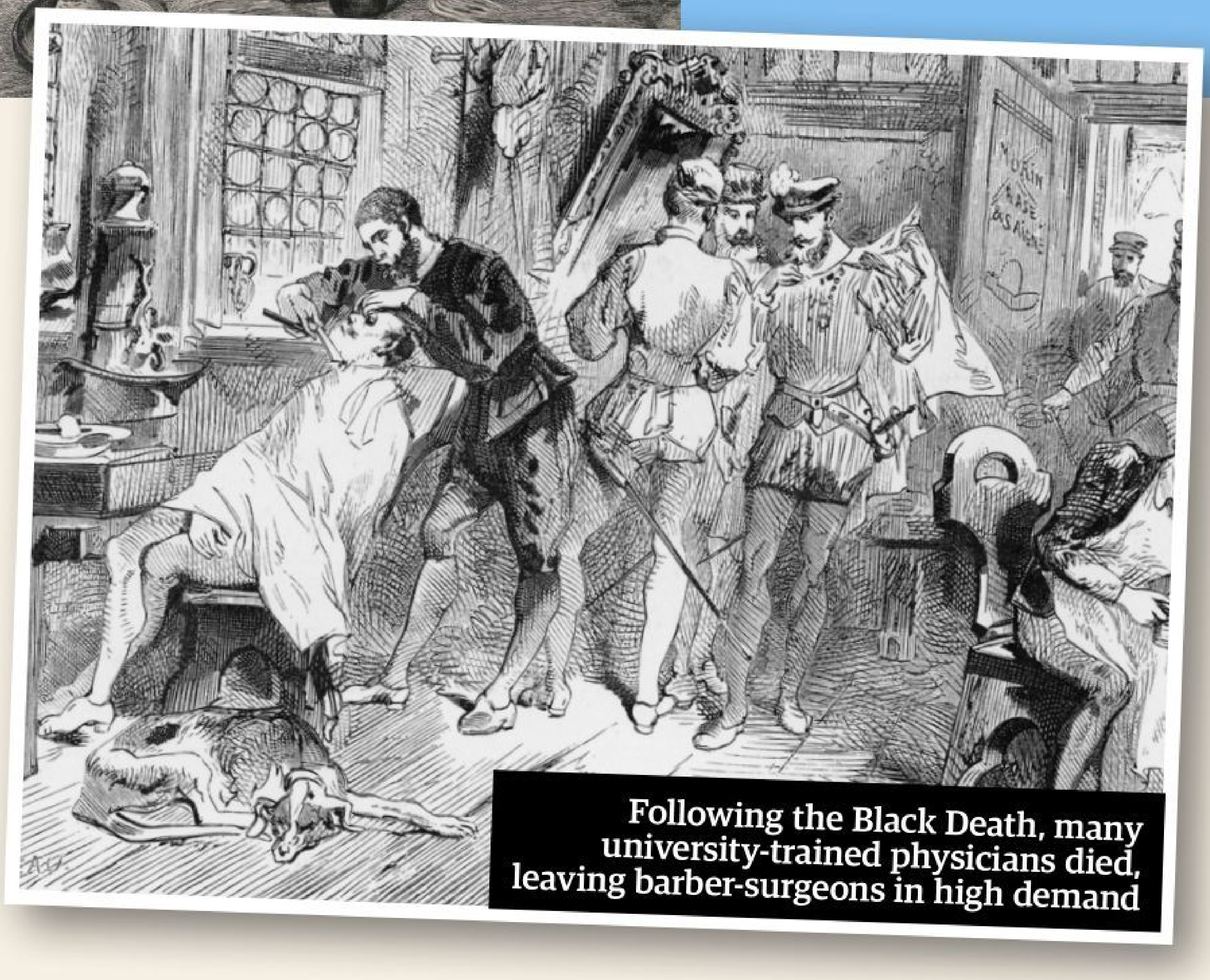
Agonising pain was an accepted part of the surgery that was offered to those who it could potentially save. Limbs were severed from the area most affected, burned with fire to purify the wound, and cauterised with a boiling oil solution to prevent the patient from losing too much blood. In a pre-biotic era, opium, henbane, mandrake and strong spirits were all that was available to numb the pain. Should the patient survive, infection often killed them as a result of either the charred and damaged body tissue unable to repair the wound, or gangrene from the shrapnel left decaying in it.

One day, when performing an amputation, Paré ran out of the cauterising solution and replaced it with his own mixture: a balm made from egg yolks, rose oil and turpentine. Paré had an anxious night's wait ahead of him as he retreated to his bed to rest up following an arduous day of surgery. The following morning, the military medic expected to find the patients treated with his concoction to be thrashing about in pain or, worse, dead. However, when he examined the two sets of patients - those who had been treated with the boiling oil solution and those who had been treated with the balm, he discovered those treated with the latter to be in a much better condition thanks to the antiseptic properties of the turpentine, compared to those treated by the former, whose wounds were red and

Paré's knowledge of how to sew up bullet wounds saved soldiers from bleeding out and dying



Paré's medical advances didn't stop at carrying out life-saving surgery, but also included helping patients post-surgery by designing prosthetic limbs



Following the Black Death, many university-trained physicians died, leaving barber-surgeons in high demand

swollen, with patients displaying a fever and in insurmountable pain. Seeing the dramatic difference between treatments, Paré decided he would only treat cases with procedures he had personally observed to be successful.

Following the death of his patron in 1539, Paré temporarily returned to Paris where he could now afford the fees for his exam, and joined the Company of Barber-Surgeons. A few months later, he married the daughter of a wine merchant, Jeanne Mazelin. Married for more than three decades, the couple had three children. Paré's medical knowledge was spreading fast, but with the invention of the printing press came the opportunity for him to further enhance the knowledge of training barber-surgeons everywhere. It was celebrated physician Jacques Dubois who encouraged Paré to write about his experiences with gunshot wounds. However, the outbreak of war between France and Spain delayed the completion of his works. It wasn't until 1545, when Paré's first book, *The method of curing wounds made by arquebus and other firearms*, was finished and published. The book drew on Pare's experiences, such as an occasion during the 1542 Siege of Perpignan when he, accompanying the French army, formed a new technique to aid in bullet extraction. Paré's views about surgery focused on the idea that amputation of limbs might be carried out, and limit the pain and death of the patient.

While Galen had been the first to suggest the use of a ligature when amputating limbs, Paré's books revived the idea as part of a successful surgery, as well as innovations such as treatments for sucking chest wounds and a cure for chronic skin ulcers. Most books of the day were written in Latin, but Paré wanted to pass his knowledge on to budding barber surgeons in the hope of producing skilled and knowledgeable medics, so instead wrote his books in the vernacular. At first, the idea was ridiculed, but the mocking ceased as more surgeons gained valuable skills required to save lives. By 1552, with his reputation growing at an alarming rate, Paré became an in-demand surgeon, and was summoned by injured French monarchs Henry II, Francis II, Charles IX and Henry III.

For almost every decade of his life, Paré published a set of works, each further advancing surgical techniques away from the outdated practices commonly accepted by surgeons. His books detailed designs that were beneficial to those who had lost limbs from surgery, granting the disabled access to artificial arms and legs. He also expanded on designs for new surgical instruments that would remove intrusive objects and make surgery easier. Paré's experience on the battlefield meant that he was one of the first surgeons to suggest severing the limb above the affected area to prevent gangrene and infection eating away at the shrapnel-filled gash. His ideas were revolutionary, but alas had to come to an end. The last book published by Paré came in 1585 as a response to an attack made on him by French doctor Etienne Gourmelen in his own book on surgery. Gourmelen was sceptical of Paré's acceptance of Galen's ligature concept in amputations, drawing on his experiences when his brother-in-law died after Paré used one to amputate his leg. Gourmelen blamed his brother-in-law's death on the failure of the ligature.

Paré died in 1590 at the age of 80 from natural causes. His legacy as the father of modern surgery continues to be highlighted in modern medicine although, thankfully, many practices from the 16th century have been progressed beyond the barbaric surgical techniques used on the battlefield.

THE BEZOAR STONE EXPERIMENT

During the 15th century, there was a long-standing popular belief that a bezoar stone could cure poisoning. The indigestible mass, often found in the stomach of a goat in the Middle East, was thought to be an antidote to toxic liquids. "Some years ago, a gentleman boasted before King Charles that bezoar was an antidote for all poisons," Paré wrote in his 1575 book *Apology and Treatise*.

Not convinced, Paré proposed an experiment. Selecting a criminal who had been sentenced to death by hanging, Paré suggested that the condemned man instead be poisoned and 'treated' with the bezoar stone. If he survived, he could go free. An hour after he was poisoned, Paré "found him on the ground on his hands and feet like an animal, with his tongue hanging out of his mouth, his eyes wild, vomiting, with blood pouring from his ears, nose and mouth".

Seven hours after he had first been administered the poison, the criminal died. "I opened his body and found the bottom of the stomach black and dry, as if it had been burned, whereby I realised that he had been given sublimate of mercury, whose force the bezoar could not stop," wrote Paré.

The bezoar stone was thought to be able to cure all types of poison until the 16th century when Pare proved this impossible

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EDWARD JENNER
FATHER OF IMMUNOLOGY

Edward Jenner developed an effective immunisation protocol against smallpox and saved the lives of millions

The dawn of the smallpox scourge is traced to ancient Egypt around 3000 BCE, when evidence of its death-dealing pustules has been discovered on the head of a mummified pharaoh. Over time, the disease claimed millions of lives, spreading across the globe through expanding trade routes, conquest, exploration and the extension of civilisation.

By the late 18th century, smallpox remained a common affliction and its mortality rate was staggering. An estimated 60 per cent of the population was likely to contract smallpox, and one-third of those died of the virus, which produced high fevers, head and muscle aches, and viscous sores that filled with fluid, erupted, and then formed scabs. Those fortunate enough to survive were often disfigured by scarring.

> **In Jenner's time, smallpox had killed ten per cent of the world's population, and 20 per cent in more populated areas**

Smallpox, therefore, plagued mankind for nearly five millennia before Edward Jenner, an English country doctor from Berkeley, Gloucestershire, unlocked the mystery of immunisation. Jenner had observed that milkmaids sometimes contracted cowpox, a disease related to smallpox but much less virulent, because of their close contact with livestock. In milk cattle, the cowpox virus caused blisters on the udders. In the case of the milkmaids, occasional blisters were formed on the hands. Though discomforting, the milkmaids soon recovered from these lesions.

The aspect of the milkmaid's circumstance that piqued Jenner's scientific curiosity was the fact that these ladies rarely contracted smallpox. The phenomenon, relatively unnoticed in previous medical observations, was enough for him to conduct further investigation. Could humans be protected from the dreaded virus if they gained immunity through exposure to the related but much less deadly cowpox?

Jenner was not the first to consider that such immunity was possible. In fact, another English physician, John Fewster, had concluded that the hypothesis was correct as early as 1768. His effort was followed by at least a half dozen other English, French and German physicians who are believed to have successfully tested the theory by 1791.

Edward Jenner: Father of Immunology

dward Jenner M.D.

Jenner pioneered the effort to eradicate smallpox and is remembered as the father of immunology

Further, a farmer in Dorset named Benjamin Jesty had deliberately infected his wife and two children with the cowpox virus amid a raging smallpox epidemic in 1774, making his family immune.

Jenner, however, bridged the critical gap from supposition to proof. On 14 May 1796, he extracted fluid, or pus, from active cowpox lesions on the hands of a milkmaid named Sarah Nelms. Jenner's patient was eight-year-old James Phipps, the son of his gardener. The physician made small incisions in both of the boy's arms and introduced the fluid taken from Nelms. In a short time, James developed a mild fever and experienced discomfort. Jenner watched and waited.

RIDDLE OF THE CUCKOO

Edward Jenner's research on the common cuckoo dispelled a widely held belief and compelled Charles Darwin to issue a revised edition of his landmark treatise *On the Origin of Species*. The cuckoo was well known to pirate the nests of other birds and lay its own eggs in the stolen space. However, it was believed that the adult cuckoo removed the eggs or chicks of the host species from the nest.

Jenner discovered an anatomical adaptation in the cuckoo chick that proved beyond doubt that it was actually the young cuckoo that ejected the host offspring. The cuckoo chick is born with a wide depression in its spine, which allows it to move eggs and other chicks out of pilfered nests during the first 12 days or so of its life. Afterwards, the depression fills in naturally, and the young cuckoo develops normally. This radical finding was not acknowledged in the scientific community at first. However, artist and avid birdwatcher Jemima Blackburn actually observed a blind cuckoo chick execute the process, validating Jenner's assertion.

The cuckoo relies on host birds to build nests, then moves in on the builders, its chick ejecting other occupants

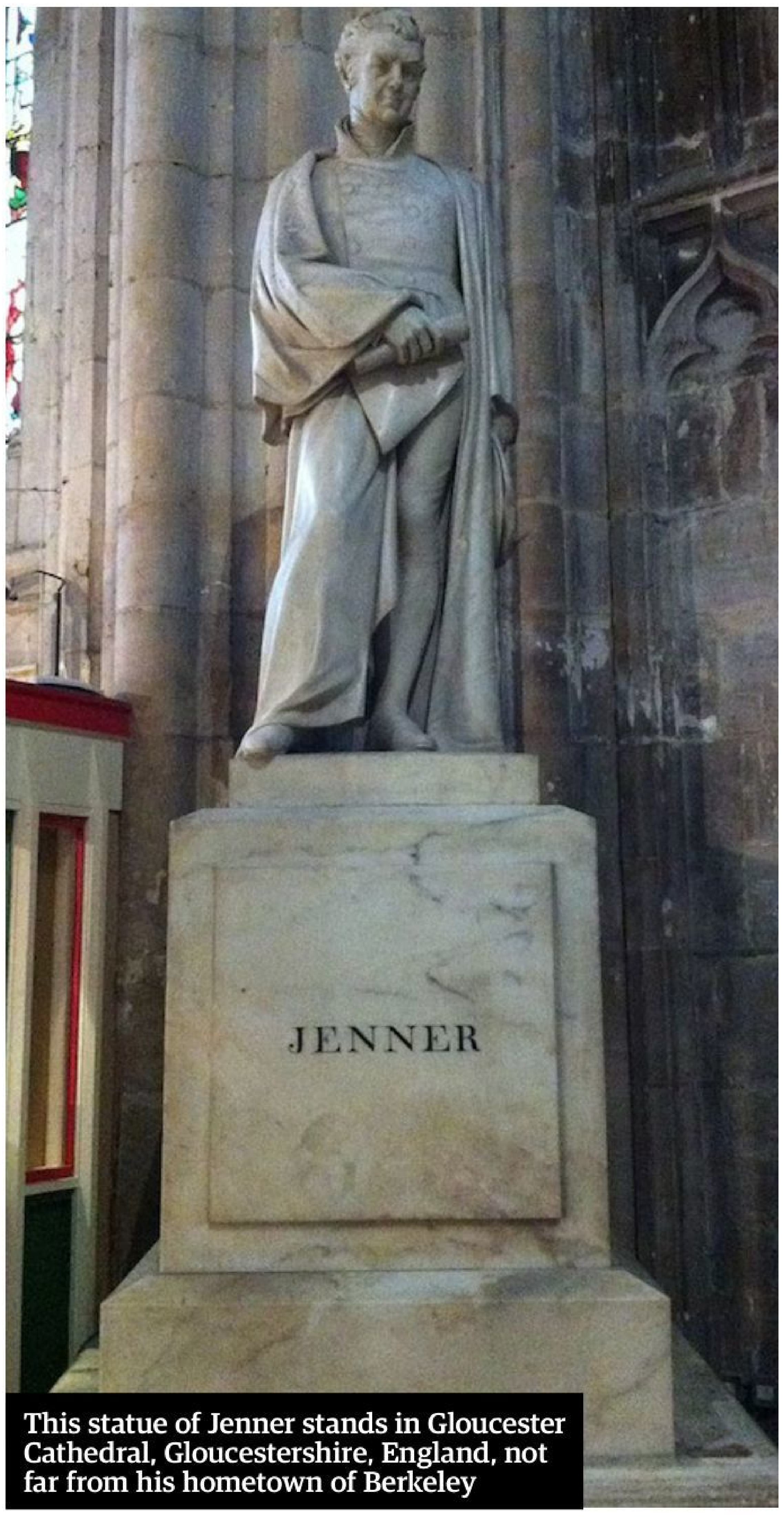
A week later, the physician wrote that young Phipps "On the seventh day...complained of uneasiness in the axilla [the area directly underneath the connection of the arm to the shoulder] and on the ninth he became a little chilly, lost his appetite, and had a slight headache. During the whole of this day he was perceptibly indisposed, and spent the night with some degree of restlessness, but on the day following he was perfectly well."

For more than 70 years, variolation was the accepted protocol for developing resistance to smallpox in Western Europe. The process typically involved rubbing or scratching fluid from smallpox pustules or powdered scabs into the skin of the patient with the hope that a minor infection might result in immunity. The concept had been brought to Great Britain in 1721 by Lady Mary Wortley Montagu, an English aristocrat who travelled extensively and first observed the practice in the city of Constantinople in the Ottoman Empire.

Jenner followed the immunity trail and six weeks after young Phipps was inoculated with cowpox virus, he tested the patient's immunity with variolous material. No infection was noted and Phipps' immunity was tested more than 20 additional times with the same result. The process was repeated with another 23 subjects. Jenner also demonstrated that the procedure was effective with transmission from arm to arm and did not require direct extraction from a cowpox pustule. He named his miracle substance 'vaccine' and the process itself 'vaccination', derived from the Latin 'vacca', meaning cow.

In 1801, Jenner wrote triumphantly, "It now becomes too manifest to admit of controversy, that the annihilation of the Small Pox, the most dreadful scourge of the human species, must be the final result of this practice." The cow that Nelms had contracted cowpox from was named Blossom, and her hide now hangs in St George's medical school in London.

When Jenner initiated his ground-breaking assault on the spread of smallpox, he was 47 years old. Well established as a physician in his hometown, he had expressed an interest in medicine and science at an early age. He was the eighth of nine children and his father, Reverend Stephen Jenner, served as vicar of Berkeley. At the age of 14, Edward was apprenticed to Daniel Ludlow, a surgeon in nearby Chipping Sodbury. For the next seven years, he learned the rudiments of medicine. He was also inoculated for smallpox, presumably via variolation, which had a lasting detrimental effect on his health. By 1770, Jenner had relocated to London under the tutelage of surgeons at St George's Hospital. Among those most prominent in his education was John Hunter, and the two collaborated and maintained contact for some time. It was probably Hunter who offered Jenner the advice of 17th-century English physician William Harvey, "Don't think; try."



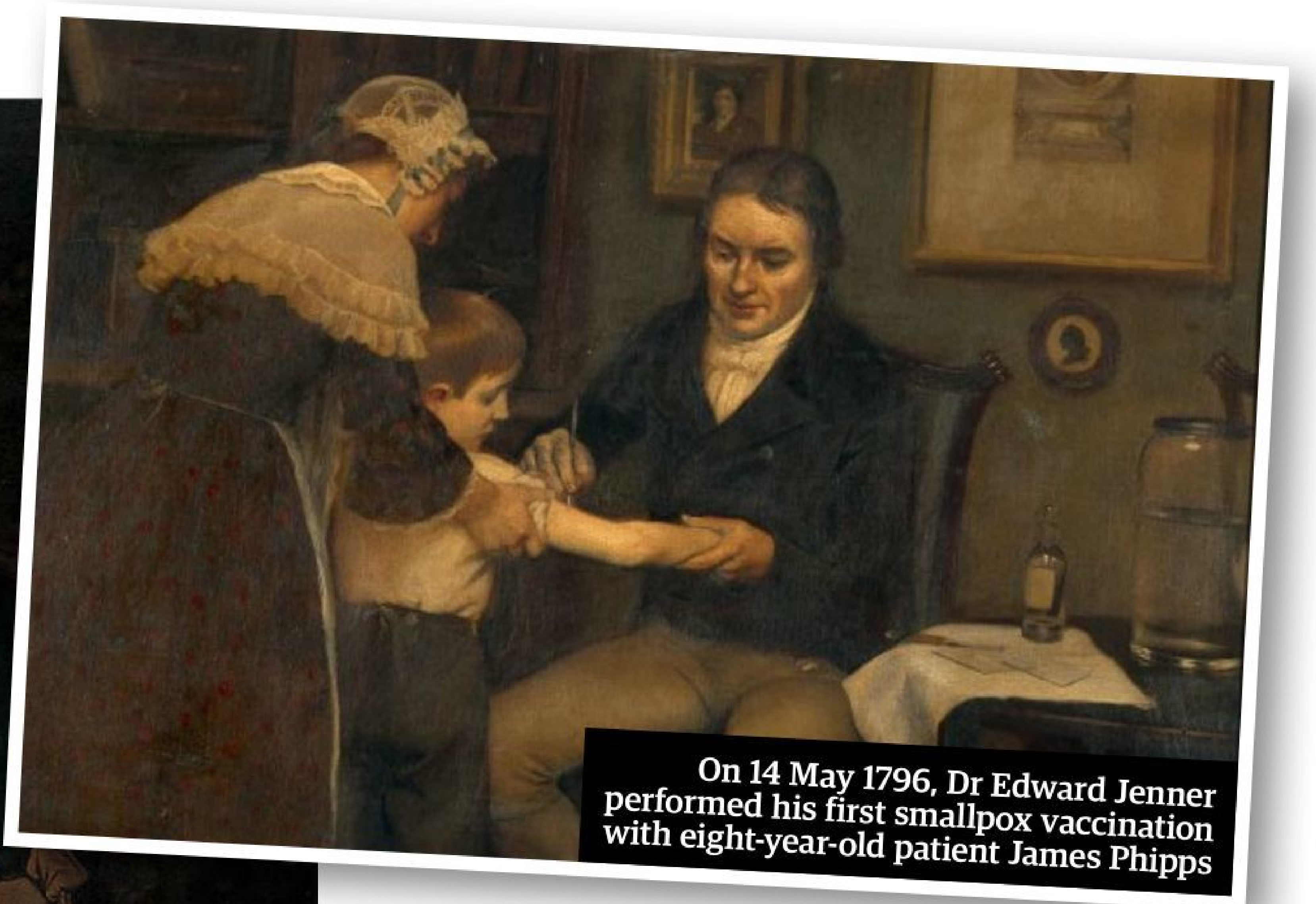
This statue of Jenner stands in Gloucester Cathedral, Gloucestershire, England, not far from his hometown of Berkeley

Making strides in the field of zoology, Jenner was the first person to describe brood parasitism of the cuckoo

Three years later, Jenner returned to Berkeley and undertook his medical practice, pursuing an interest in local wildlife and advances in medicine as he was able. He also participated in the Gloucestershire Medical Society, popularly known as the Fleece Medical Society because its meetings were held at the local Fleece Inn in Rodborough, and he joined another medical group that met near Bristol. Society members discussed popular topics and presented observations and papers concerning medical issues. Jenner produced works on cardiac valve disease, ophthalmia, inflammation of the eye,

"A revered member of medical and academic communities, Jenner was conferred honorary memberships"

In this 1910 painting, Jenner advises an English farmer to have his family vaccinated against smallpox



On 14 May 1796, Dr Edward Jenner performed his first smallpox vaccination with eight-year-old patient James Phipps

and angina pectoris, chest pain typically associated with the heart.

In 1788, Jenner was elected to the prestigious Royal Society, the world's oldest national scientific institution, with the recommendation of his friend, Hunter, and following the publication of a well-received study on the life and habits of the common cuckoo. In March of the same year, he married Catherine Kingscote, and the couple had two sons and a daughter. In 1792, he earned a medical degree from the University of St Andrews in Scotland. Catherine died of tuberculosis in 1815.

In 1803, Jenner became president of the Jennerian Society, concerned with promoting vaccination

Confident in the integrity of his findings, Jenner produced a paper on his work to thwart the spread of smallpox and submitted it to the Royal Society in 1797. The initial submission was rejected as inconclusive but the pioneer was undeterred. Among the subsequent patients in his study was his own 11-month-old son. After the Royal Society's acceptance of a more thorough report, he remarked, "The joy I felt as the prospect before me of being the instrument destined to take away from the world one of its greatest calamities was so excessive that I found myself in a kind of reverie."

When Jenner's study was made public, it was not immediately accepted. Clergymen decried introducing infected material from an animal into a human, while others scoffed. Cartoonists drew images of people sprouting the body parts of cattle after being vaccinated. Nevertheless, the advantages of vaccination over prior methods of obtaining immunity were obvious and the procedure became preeminent. Jenner soon left his medical practice to pursue additional work in immunology. In 1803, he established the Jennerian Institution, dedicated to the expansion of smallpox immunisation and the future eradication of the disease. Although this society ceased operation six years later, the government assisted in the formation of the National Vaccine Establishment. Jenner objected to the composition of this group's leadership and resigned his post as a director.

A revered member of medical and academic communities, Jenner was conferred honorary memberships in several medical societies for his extensive work, and in 1821 he was appointed physician extraordinary to King George IV. He also became mayor of Berkeley and served as justice of the peace. Throughout his life, Jenner maintained an interest in zoology and in 1823, he presented a study titled *Observations on the Migration of Birds* to the Royal Society. He died of a stroke that same year.

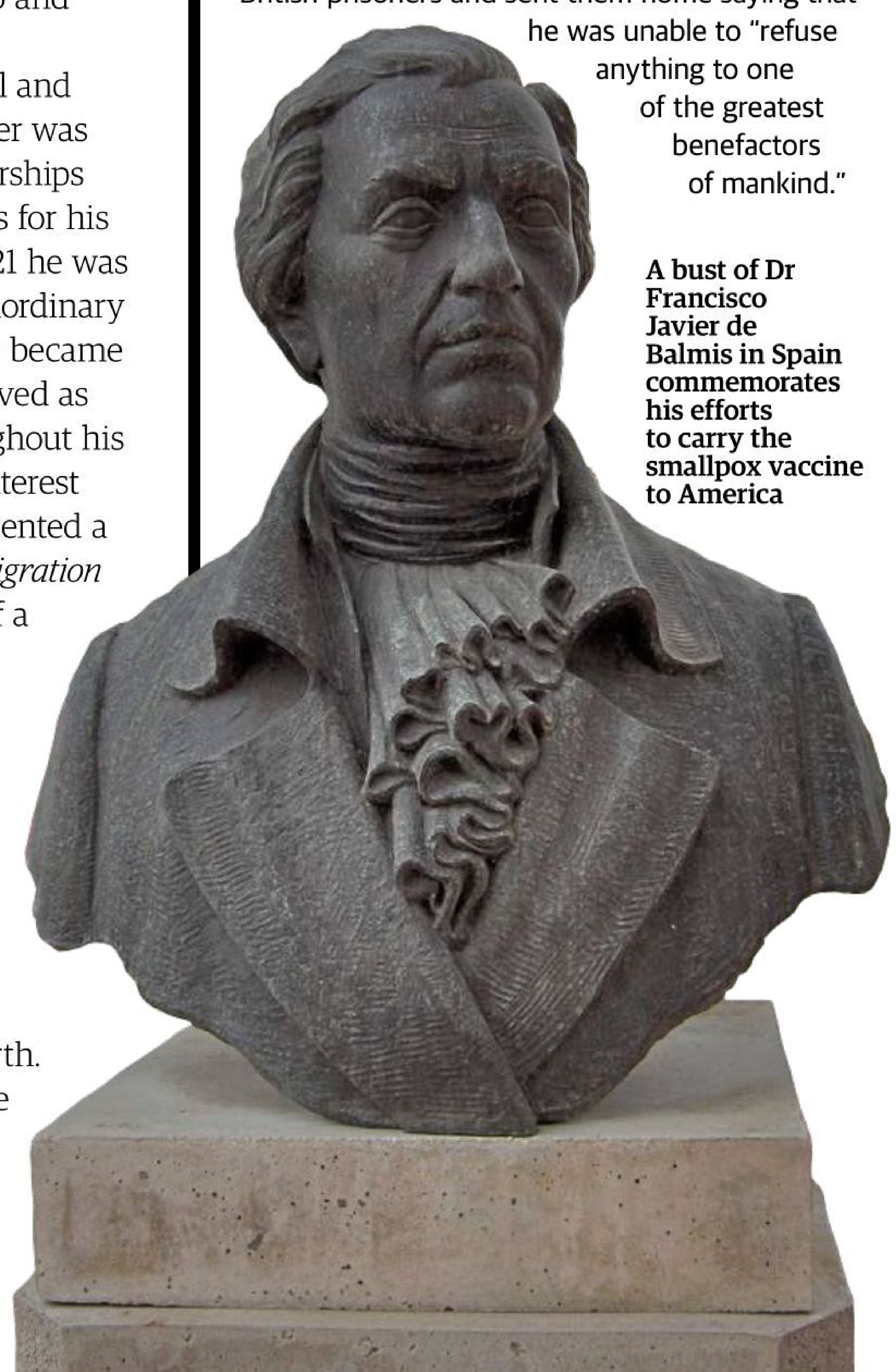
Jenner is remembered as the father of immunology, and his work is rightly credited with saving millions of lives and opening the door to future research that has resulted in effective vaccines against numerous potentially deadly diseases. In 1979, more than 150 years after his death, the World Health Organization declared smallpox eradicated from the face of the Earth. Only laboratory samples of the virus and the fading memory of its horror remain.

Vaccines in love and war

Dr Francisco Javier de Balmis, a Spanish physician, undertook an expedition to carry the smallpox vaccine to America, sailing from Spain in 1804. He also travelled to the Philippines, and Edward Jenner observed, "I don't imagine the annals of history furnish an example of philanthropy so noble, so extensive as this."

In North America, the vaccine reached Texas and further south Balmis further convinced the viceroy of New Spain to have his son vaccinated while in Mexico. He also wrote a pamphlet titled *Instructions for the Introduction and Conservation of the Vaccine*. After his death, an associate continued to spread the vaccine through the mid-1840s.

When Jenner introduced his vaccination process, Great Britain was at war with Napoleonic France, and French emperor is believed to have had his soldiers vaccinated. According to the Royal Society, at Jenner's request Napoleon also released his British prisoners and sent them home saying that he was unable to "refuse anything to one of the greatest benefactors of mankind."



A bust of Dr Francisco Javier de Balmis in Spain commemorates his efforts to carry the smallpox vaccine to America

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LOUIS PASTEUR
MASTER OF MICROBIOLOGY

Meet a man who made many pioneering scientific discoveries, but most famously the process that purifies many foods, which is still in use today

Pasteurisation is a common practice today. For more than a century the process that kills microbes, purifying an array of food and drink from milk to beer to canned products, has been the legacy of the 'father of microbiology', French scientist Louis Pasteur.

Pasteur also conducted landmark studies in the fields of biology and chemistry, pushing the frontiers of medical science and the treatment of infectious diseases to new heights. He is considered a founder of microbiology for his work on fermentation, support of the germ theory that led to milestones in the development of rabies and anthrax vaccines, and his discovery of anaerobic bacteria. His work on molecular structure resulted in the discovery of mirror image organic molecules.

> Pasteur was a true genius whose work in chemistry was characterised by his extraordinary experimental skill

While his scientific work was sometimes controversial, Pasteur is credited with revolutionising food preservation, preventing the collapse of the European silk industry, and saving countless lives with his discoveries and vaccine development. Ironically, such achievements appeared beyond his grasp when he was a child. His earliest teachers found his academic prowess average.

Pasteur was born in Dole, east France, on 27 December 1822. His father, Jean-Joseph Pasteur, was a veteran of the army of Napoleon Bonaparte. His mother, Jeanne-Etiennette Roqui, had already given birth to a daughter, while a son had died in infancy. Later two more daughters were born. The elder Pasteur worked as a tanner, and the family lived moderately, moving to the village of Marnoz in 1826 and to Arbois, where Louis spent most of his childhood, the following year.

When Pasteur entered school at the École Primaire Arbois in 1831, his father had already taught him to read. Still, Pasteur's interest in academics was shallow. He preferred fishing and sketching. By the time he reached secondary school, he was receiving tutoring from a family friend, Buousson de Mairet. His performance improved, and his parents hoped he might become a teacher.

When he was 15, Pasteur was sent to the Institution Barbet, a Paris boarding school, to prepare for the entrance examination to the prestigious École

Louis Pasteur: Master of microbiology

Louis Pasteur contemplates a laboratory specimen during one of his many courses of study and discovery

The Pasteur Institute was founded in Paris in 1887 and continues to lead efforts to combat infectious disease

The Pasteur Institute

Louis Pasteur's work in developing a rabies vaccine was a catalyst for the founding of the Pasteur Insititute, a renowned research centre in Paris dedicated to disease prevention and the continuing study of microorganisms. The institute remains active today.

Fundraising for the Pasteur Institute began in 1887, and a year later its work began. During World War I, the Institute produced 670,000 doses of typhoid vaccine to protect Allied troops. In World War II, a worker involved with the French Resistance secretly provided typhoid-causing bacteria to factory workers who infected butter destined for German troops. Since 1908, eight Institute researchers have received the Nobel Prize in Physiology or Medicine. Most recently, Françoise Barré-Sinoussi and Luc Montagnier shared the 2008 Nobel Prize for their isolation of two HIV viruses that cause AIDS in humans. Other advancements in treatment for influenza, polio, bubonic plague, tuberculosis, tetanus, yellow fever, and diphtheria have been achieved.

Pasteur spent his last year living in an apartment at the Institute, and his wife resided there until her death in 1910. Pasteur Institute facilities have expanded to 32 locations in 29 countries around the world.

Louis Pasteur sat for this portrait on 1 January 1895, the year he died of a stroke at age 72

> "His discovery led to progress in pharmaceutical development and the fields of chemistry and biochemistry"

Normale Supérieure (ENS). Life away from family was intolerable. After just two weeks, his father allowed the homesick boy to return to Arbois. In 1839, he enrolled at the Royal College in Besançon, 49 kilometres from Arbois. Applying energy to the task, he received a diploma in philosophy in 1840. Working as a teaching assistant at Besançon, he studied mathematics, physics, and chemistry but failed the examination for a second degree in 1841. Although he passed the next year, his grades in chemistry were unimpressive.

Still aspiring to enter ENS, Pasteur attended classes at the Lycée Saint-Louis. He successfully passed the ENS examination and received a science degree in 1845. He then conducted research at the Dijon Lycée. Rather than accepting a teaching position in the town of Tournon, he became a graduate assistant at ENS under Professor Antoine Jérome Balard, who believed the young scientist showed promise. Pasteur submitted theses in chemistry and physics, earning a doctorate. In 1848, at age 25, Pasteur became a professor of chemistry at the University of Strasbourg. In the same year, he made his first notable scientific discovery.

For some time, scientists had examined the properties of tartaric acid, a chemical present during the fermentation process of wine. Polarized light was used in the study, passing through a solution of dissolved tartaric acid, which rotated the angle of the plane of the light. Pasteur referred to a second compound, paratartaric acid, also present during fermentation. While other scientists had assumed that the two chemicals were identical, Pasteur discovered that paratartaric acid did not rotate the polarized light. Therefore, there must be a structural difference between the chemicals.

Pasteur was born in the town of Dole in eastern France, and his father worked as a tanner

Further investigation revealed that the two crystalline structures were mirror images of one another. Present in the same solution, there was no rotation of polarized light. He had proven that in determining a chemical's behaviour it was necessary to examine molecular structure and shape, not just composition. His discovery led to progress in pharmaceutical development and the fields of chemistry and biochemistry. While at the University of Strasbourg, he married Marie Laurent, the daughter of the university rector, on 29 May 1849. Two of their five children survived to adulthood.

Pasteur gained notoriety and in 1854, he became dean of the Faculty of Sciences at the University of Lille. A student, Emile Bigo-Daniel, whose father owned a local distillery that converted sugar beets to alcohol through fermentation, brought an issue to the professor's attention. Pasteur adhered to the germ theory; the hypothesis that microbes introduced from outside their hosts cause infectious diseases and that fermentation and putrefaction are caused by airborne organisms.

Controversy surrounds Pasteur's incorrect claim of inventing the anthrax vaccine

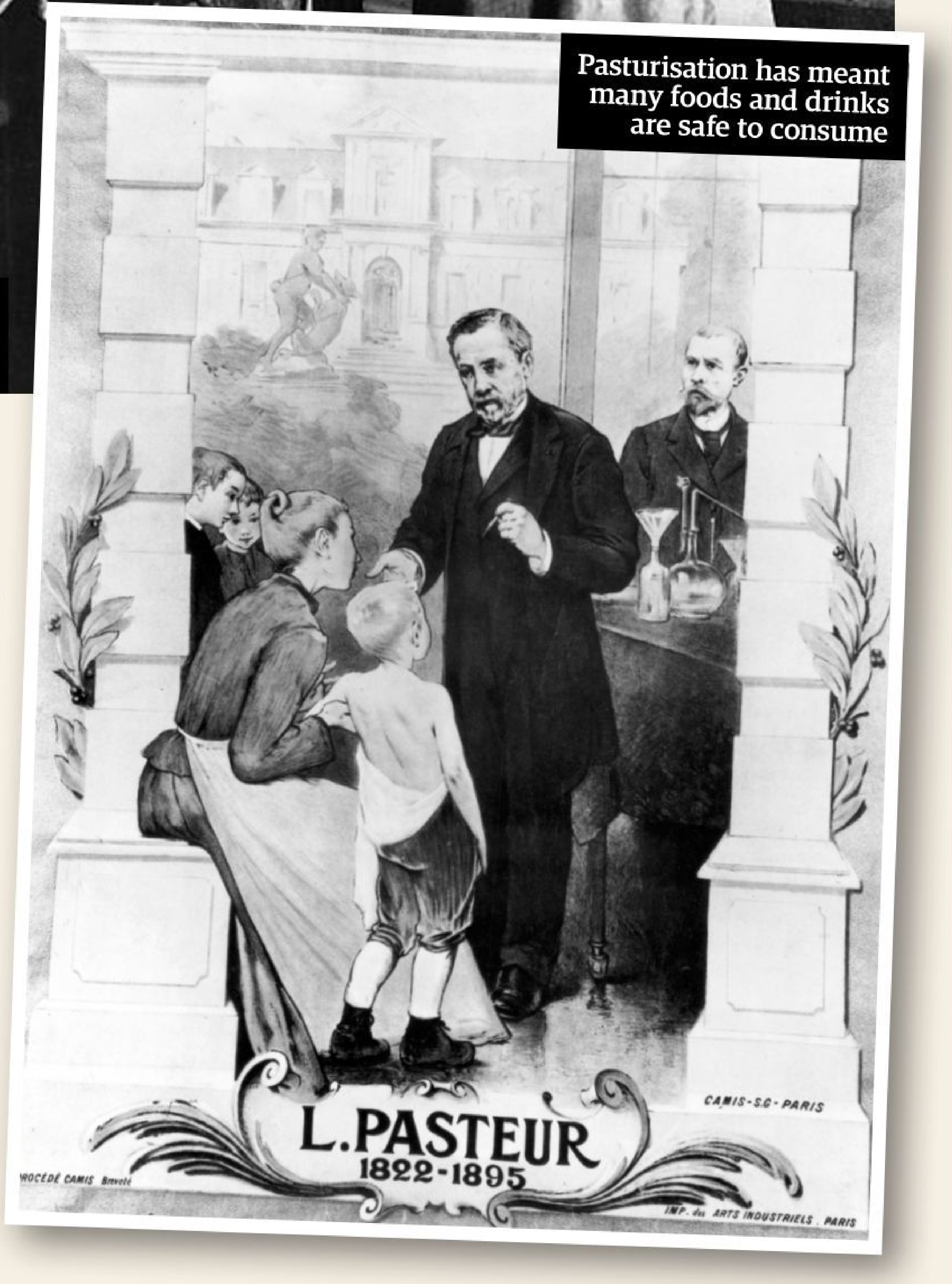
Pasteur contemplated the process of fermentation, the conversion of sugar to alcohol, and considered the work of Theodor Schwann two decades earlier.

Schwann believed that fermentation was a process involving living yeast rather than the decomposition of the expired microorganism. During four years of experimentation, Pasteur proved that Schwann's assertion was correct. Relentless in his work, he enlisted his wife's help, who wrote in 1856, "Louis is now up to his neck in beet juice. He spends all his days in the distillery."

Pasteur published his findings in 1858 and further noted that a specific strain of yeast causes milk to sour by converting sugar to lactic acid. He also devised a process to destroy microbes by heating to a boil and then cooling liquids. His initial test of pasteurisation was successfully completed on 20 April 1862.

By then he had returned to ENS and paid personally for the establishment of an attic laboratory to continue conducting research, which resulted in the discovery of anaerobic microorganisms, a previously unknown form of life that existed without the need for air or oxygen. He further dispelled the theory of spontaneous generation, that living organisms were produced from non-living matter. Through extensive

Louis Pasteur works in his laboratory. Although he is one of history's great scientists, controversy surrounds some of his efforts.



Pasturisation has meant many foods and drinks are safe to consume

experimentation with sterile and non-sterile components, he proved that microorganisms did not grow in sterile solutions until non-sterile air was introduced. The only conclusion was that the microorganisms were present in the non-sterile air.

The intensity of his labour took its toll on Pasteur's health, and he had suffered a stroke at the age of only 45 in 1868; however, he continued to pursue additional discoveries. Familiarity with microbes reinforced his belief in the germ theory and led to work with infectious disease. Experimentation with cultures of bacteria that caused chicken cholera led to better understanding of immunity and development of a vaccine in 1879.

Pasteur also studied anthrax, a disease responsible for many livestock deaths. At the same time, veterinary surgeon Jean Joseph Henri Toussaint was conducting research on the disease. While Toussaint had used dead anthrax bacteria to develop a vaccine, Pasteur favoured a weakened form of the pathogen. In preparation for a demonstration before the Société d'agriculture de Melun, Pasteur covertly developed vaccine with a process similar to Toussaint's.

Pasteur also embarked on a quest to develop an effective vaccine against rabies, a disease that is virtually always fatal when contracted by humans. Pasteur isolated the rabies virus in rabbits and extracted and dried nerve tissue to weaken the pathogen sufficiently. After testing the vaccine in dogs, Pasteur, who was not a licensed physician, risked arrest with the supervised inoculation of a nine-year-old boy, Joseph Meister, who had been bitten by a rabid dog.

Over an 11-day period beginning 6 July 1885, Meister received 13 inoculations, each time with the vaccine containing a stronger form of the rabies virus. Ninety days after the final inoculation, Pasteur examined the patient and found him healthy. By the next year, Pasteur had inoculated more than 350 people. Only one case of rabies emerged from these. Pasteur was a national hero.

Partially paralysed since his stroke, Pasteur's health declined steadily by the 1890s. He was weakened by a second stroke in 1894, and a third claimed his life the next year at 72. Pasteur was interred at the Notre-Dame Cathedral in Paris; his remains were later removed and reinterred in the Pasteur Institute.

For all his contributions and accolades, Pasteur's career is tinged with controversy. During his lifetime rivals and observers questioned his ethics and practices. In addition to the appropriation of Toussaint's anthrax vaccine procedure, Pasteur's laboratory notes state that he had tested the rabies vaccine on only 11 dogs rather than the 50 he asserted publicly. Apparently, he had also inoculated two individuals secretly prior to the publicised success with Meister. Another scientist, Antoine Béchamp, claimed the discovery of the fermentation process, disputing Pasteur's claim until his death.

In 1878, aged 55, Pasteur instructed family members to keep his laboratory journals private. This evidence of the great scientist's work eventually passed to his grandson and last surviving male descendant, Pasteur Vallery-Radot, who donated the papers to the National Library of France. They became available after Vallery-Radot died in 1970. Details of Louis Pasteur's triumphs, setbacks and deceptions were revealed. Nevertheless, the body of Pasteur's scientific contributions stands on its own merit. His legacy is one of beneficial discovery and scientific advancement, enhancing the human experience.

THE RIDDLE OF THE SILKWORM

Although he had no background in biology, Louis Pasteur became the saviour of the European silk industry in the late 1860s. When diseases ravaged the silkworm population, sending production of the precious textile component plummeting, government tax revenues and farmers' profits followed. Pasteur accepted the challenge to determine the source of the infections and develop a protocol to eliminate them. He went to the town of Alés in 1865 and worked there for the next five years.

The two devastating diseases had been identified as pébrine and flacherie. Soon, Pasteur noted that silkworms with pébrine were covered in otherwise unattached cells, or corpuscles. Further study revealed that the corpuscles were the cause of the disease rather than a symptom and that the disease was hereditary. To curb the malady, female moths were examined after laying eggs. If they were determined to carry pébrine, the eggs were destroyed. Pasteur also believed that microorganisms, probably bacteria, were causing flacherie, although later study pointed toward a viral culprit. Still, Pasteur advocated the use of moths that were not infected to produce eggs for the silk industry. Pasteur's contribution to the welfare of the European economy brought him further fame.

Silkworms produce fibres that are valuable in the textile industry, and Louis Pasteur spearheaded efforts to quell diseases among them

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FLORENCE NIGHTINGALE
MOTHER OF MODERN NURSING

How one woman's intrepid determination changed the face of nursing across the world forever

Florence was not born to be a nurse – in fact, she was not born to be anyone remarkable at all. Born to a rich, upper-class family in the 1820s, her path was laid out neatly before her. She was to marry a similar rich, upper-class man and become a wife and mother. Fortunately for history, and us today, Florence developed a habit of straying from the path.

Named after the city of her birth in Florence, Italy, she moved to England in 1821 and was brought up in the family's various homes in Embley, Hampshire, and Lea Hurst in Derbyshire. Her father was an extremely wealthy landowner and the family associated with those in the very highest circles of British high society. However, her father defied traditions with his strong belief that women should be educated to be more than mothers and wives. He educated Florence and her sister in Latin, Greek, philosophy, history and, unusually, writing and mathematics – two pursuits that were regarded as exclusively male at the time. Florence particularly excelled in mathematics and science, developing a love of recording and organising information, as can be seen by her excessive documentation of her shell collection. These skills would prove essential in her later life.

As a child, Florence excelled in maths and science and documented her shell collection with precise tables and lists

When Florence turned 18, she accompanied her father on a tour of Europe during which she met Mary Clarke. The bond between the two women was instant and the effect Clarke had on Florence was immense. Clarke was a forthright, bold woman who didn't care for her appearance and had little respect for the upper-class women she believed led inconsequential lives. For Florence, it was her first encounter with a woman who showed her that females could be equal to men, which was far from the opinion of Florence's own conservative mother.

In fact, Florence's mother had very traditional aspirations for her oldest daughter, wishing her to marry and lead a life of domesticity. The girl was certainly eligible, striking and intelligent, but that was not the life that appealed to Florence. In 1837, Nightingale experienced what she believed was a call of God, imploring her to dedicate her life to the service of others. Florence became convinced that her path in life was that of nursing – a revelation that her parents were not pleased about. At the time, nursing was viewed

Nightingale was fluent in four languages: English, French, German and Italian

MOTHER SEACOLE

Florence was far from the only remarkable nurse working in the Crimean War – Mary Seacole was an incredibly significant woman who also rose to prominence thanks to her efforts towards the nursing efforts in the war. Born in Jamaica to a Jamaican mother and Scottish father, Seacole learned her nursing skills from her mother who ran a boarding house for invalid soldiers. Through her frequent travels, she combined traditional medicine ideas with European ones.

In 1854, her request to be sent to the frontline of the war effort was rejected. However, this enterprising woman wouldn't take no for an answer and funded her own trip, setting up the British Hotel to care for sick soldiers. Incredibly fearless, Seacole even visited the battlefield to care for the wounded and dying. She was beloved by the soldiers who referred to her as Mother Seacole, and at the time her reputation was on par with Nightingale's.

Unfortunately, after her death Seacole all but vanished from public consciousness, which many cite as an example of hidden black history. However, by the 21st century she became a much more prominent figure, being posthumously awarded honours and having many medical establishments named after her. Although some argue that her contributions to medicine have been exaggerated, she certainly did all within her power to ease the suffering of soldiers when no cures existed. The hot tea and lemonade she served may not have saved lives, but she remains a beacon of kindness to one's fellow man in the most trying of times.

Seacole was voted the greatest black Briton in 2004

as a lowly profession performed only by the poor, widows and servants. Nightingale's parents refused to allow her to train in Salisbury, hoping the desire would fade away. Florence, however, was dedicated and stubborn. She even declined a proposal of marriage after a long courtship believing it would intervene with her nursing aspirations.

Defying her parents' wishes, she worked hard to train herself in the art and science of nursing, and she visited hospitals in London, Paris and Rome, learning everything she could along the way. Her travels took her as far as Greece and even Egypt, where she again professed to have experienced godly intervention saying that "God called me in the morning and asked me would I do good for him alone without reputation". By 1850, both parents finally yielded to Florence's iron determination and her father granted her permission to train as a nurse in Germany.

Three years later, and almost a decade after her crusade for independence began, Florence finally achieved her ambition of becoming a nurse when she accepted the post of superintendent at a women's hospital in Upper Harley Street. But Nightingale's work was far from over. In October 1853, the Crimean War had broken out and it became one of the first wars in history to become widely reported and photographed. When Florence read about the horrific conditions suffered by the wounded, she was motivated to spring into action. On 21 October 1854, Florence and a staff of volunteer nurses trained by herself, and 15 Catholic nuns were sent to the Ottoman Empire.

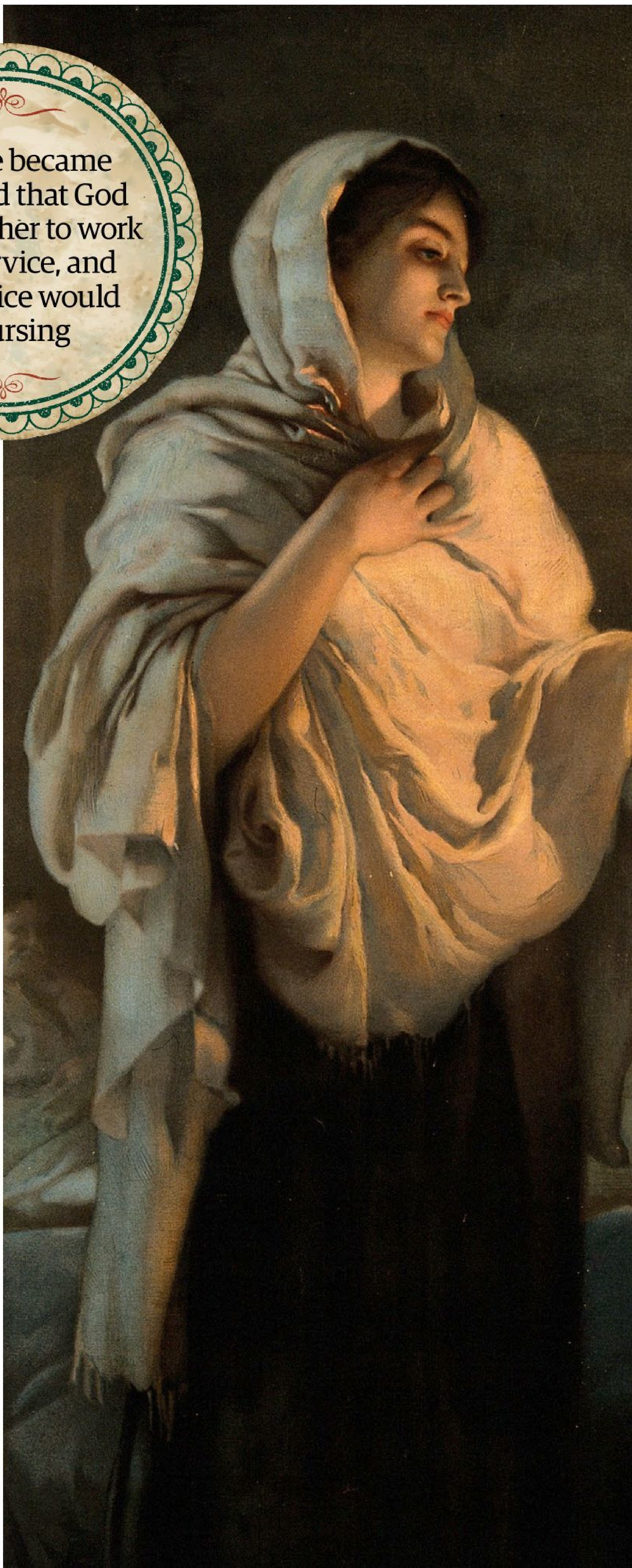
Florence became convinced that God has called her to work in his service, and this service would be nursing

Florence wasn't prepared for what awaited her in the Selimiye Barracks in Scutari. Not only were the medical staff incredibly overworked, but the care they were delivering was poor, medicines were running dangerously low, hygiene standards were nonexistent and none of the officials seemed to care. The floor of the hospital was described as being an inch thick with human faeces. Appalled, Florence rapidly mobilised her staff to clean the hospital and ensure that the soldiers were properly fed and clothed.

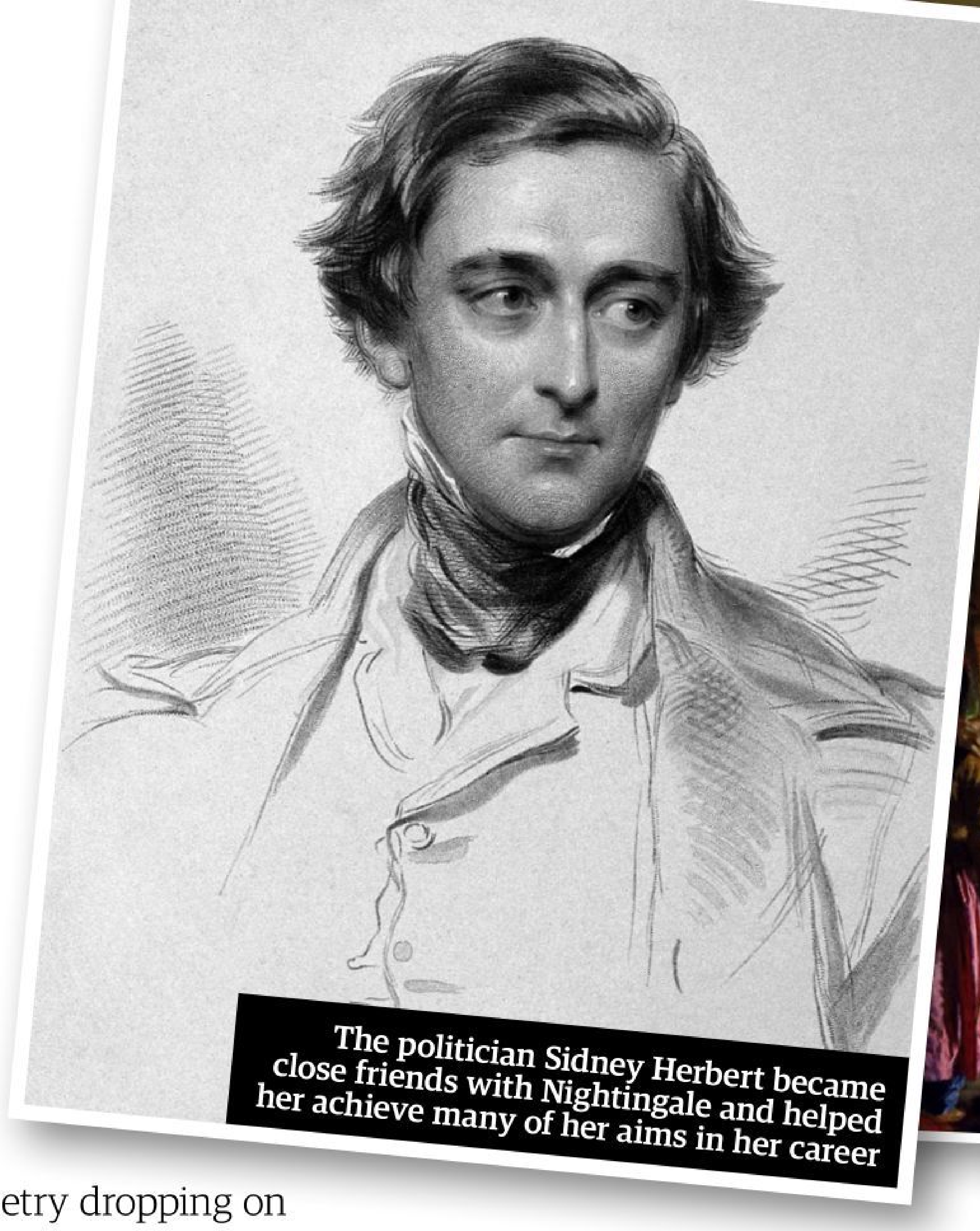
Determined to implore the government to take action against the dreadful conditions the soldiers were nursed under, Nightingale sent a plea to *The Times* for the government to act – and act they did in the form of Renkioi Hospital. Built in England and shipped over, the new civilian facility had a death toll that was less than one-tenth of that suffered in Scutari.

It is estimated that Florence managed to reduce the death rate from 42 to two per cent thanks to her pioneering improvements and those she implored the Sanitary Commission to make. Some of these were things that we take for granted today such as implementing handwashing procedures and other neglected hygiene practices. Thanks to Florence's recommendation, the sewers of the hospital were also flushed out and the ventilation was improved. The death rates from illnesses such as typhus, typhoid, cholera and dysentery, which were killing more soldiers than battle wounds, were drastically reduced.

Although Florence herself never claimed credit for the improved conditions, her work had started to make a pioneering name for herself. To the soldiers under her care she was known as a figure of authority, with one British soldier writing: "It



"When Florence read about the horrific conditions suffered by the wounded, she was motivated to spring into action" would be a brave man that dare insult her… I would not give a penny for his chance." However, when a portrait of Florence carrying a lamp, tending to patients, appeared in an article in *The Times*, she was given her famous nickname 'The Lady with the Lamp'. She instantly inspired an army of committed Nightingale fans. She was described as a "ministering angel… as her slender form glides quietly along each corridor, every poor fellow's face softens with gratitude." Her enterprising work in Crimean War hospitals was hailed by the press and her family had to endure a wave of poetry dropping on their doorstep from adoring fans. Florence's image was even printed on souvenirs and she achieved Victorian celebrity status. The lady herself, however, was not so keen on this attention, and she adopted a pseudonym, Miss Smith, to avoid being mobbed by the adoring masses.


The politician Sidney Herbert became close friends with Nightingale and helped her achieve many of her aims in her career

Queen Victoria was a big fan of Nightingale and her work in Crimea, awarding her a special brooch as a thank you

It was the strong visual of Florence grasping a lamp in a dark hospital that captured the nation's sympathy and catapulted her to stardom

Considering Florence had defied tradition to become a nurse, this newfound celebrity was surprising but immensely powerful. This was a power the Lady of the Lamp did not intend to squander and she sprang into action upon returning from the war. Florence began collecting evidence and in league with her staunch supporter Queen Victoria, she persuaded the government to set up a Royal Commission to look into the health of the army. Florence and the commission concluded that poor living conditions were the main cause of death in the hospitals, with 16,000 of 18,000 deaths due to preventable diseases spread by poor sanitation. She focused on promoting sanitary living conditions in all hospitals and with immense support behind her, the Nightingale Fund was created to help train new nurses in her techniques.

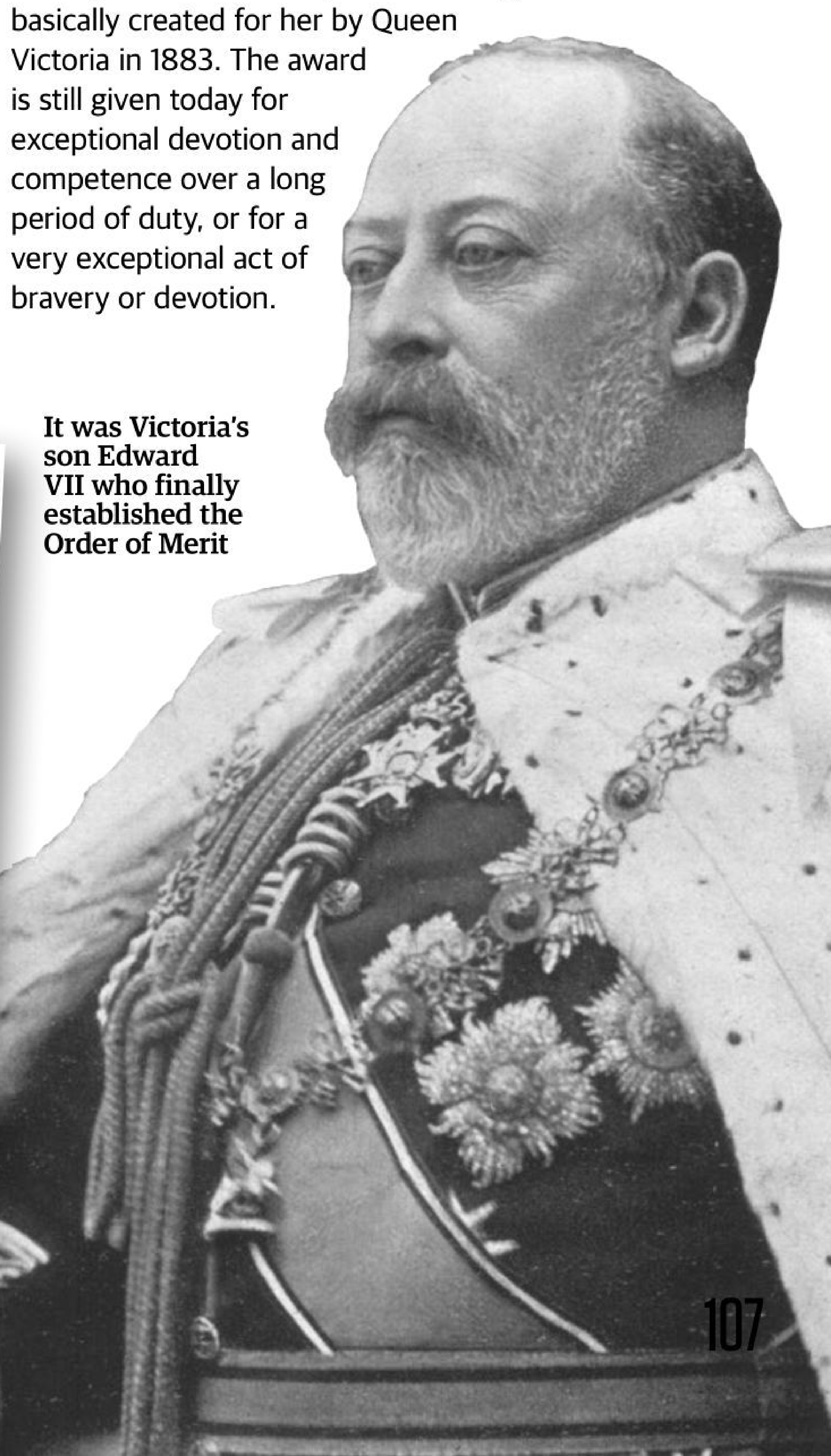
With £45,000 raised through the Nightingale Fund, Florence set up a training school at St Thomas' Hospital and went on to work at the Liverpool Workhouse Infirmary by May 1865. Perhaps one of her most remarkable contributions to medicine, however, was her book, *Notes on Nursing*, which was published in 1859. This book was not only used in her school by her students,

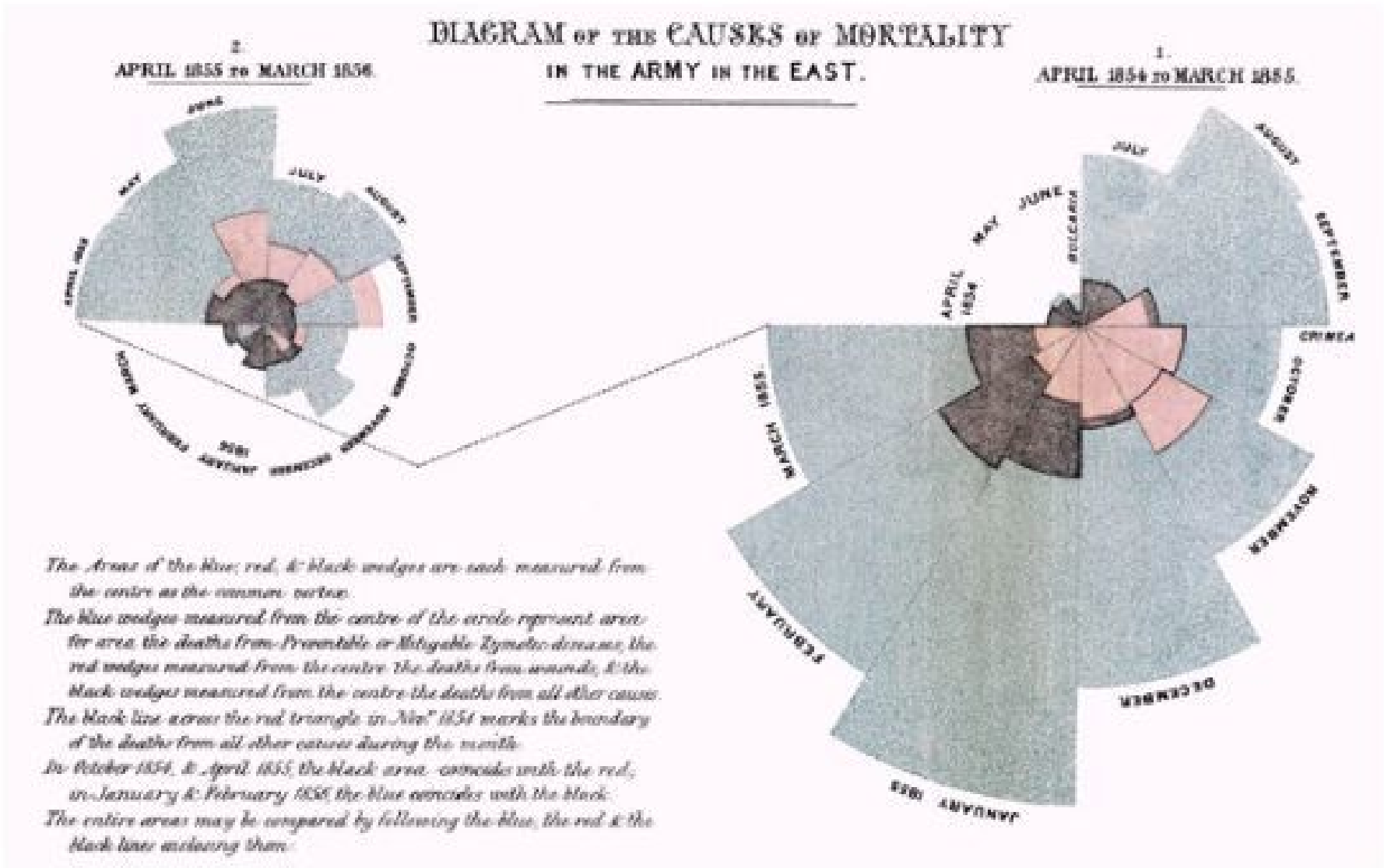
Before Nightingale transformed the profession, the wage for nurses was so bad many engaged in prostitution on the side

The Order of Merit

The Order of Merit is an award that was created to acknowledge distinguished service in the armed services, science, art, literature or the promotion of culture. First established by Edward VII in 1902, the award can only be given out at the discretion of the reigning monarch, with a maximum of 24 living recipients permitted at any one time. The idea of an Order of Merit was discussed far before it was installed in 1805 following the battle of Trafalgar, and again later by Queen Victoria. Since its installation it has not been an easily won honour, with politicians lobbying for candidates, but the monarch usually remains guarded about their decision. In 1907, Florence Nightingale became the first woman to receive the honour.

However, it wasn't only the Order of Merit Florence received for her work – she also became the first recipient of the Royal Red Cross. This military honour for exceptional nursing was basically created for her by Queen Victoria in 1883. The award is still given today for exceptional devotion and competence over a long period of duty, or for a very exceptional act of bravery or devotion.


It was Victoria's son Edward VII who finally established the Order of Merit



Nightingale designed this diagram to illustrate the causes of death in the East

Nightingale, the maths whizz

Although many remember Florence for her role as the saintly nurse, perhaps her most notable ability that helped save countless lives was not compassion but mathematical genius. From an early age, Florence naturally took to mathematics and she was especially skilled in recording and organising information.

Over her life, Florence became a pioneer in statistics, graphs and the visual presentation of information. She frequently utilised the pie chart, which was a relatively new concept at the time. Today she is credited as having developed the polar area diagram, also known as the Nightingale rose diagram. This graph helped her to represent sources of patient mortality in an easy to understand manner.

Her very visual representations of findings meant they could be understood by civil servants and members of parliament who would have struggled to understand the long, complex written reports. Her contribution was so significant that in 1859, the Royal Statistical Society admitted her as its first female member. She also later became an honorary member of the American Statistical Association. Without her natural mathematical ability and statistical pioneering, it is unlikely Florence would have been able to make the strides forward in medicine that she achieved.

Nightingale took it upon herself to train as many nurses as she could in her pioneering new techniques

but also by those nursing in their own homes. Florence was all about accessibility and she wanted to be sure that anyone, regardless of class or ability, could read the book and follow the practices set out within it. For the era, the simple rules of sanitation and health within were revolutionary and the volume is considered a classic in the history of nursing. It was designed to help those who were unable to pay for private healthcare and it meant that people could care for their sick relatives and friends.

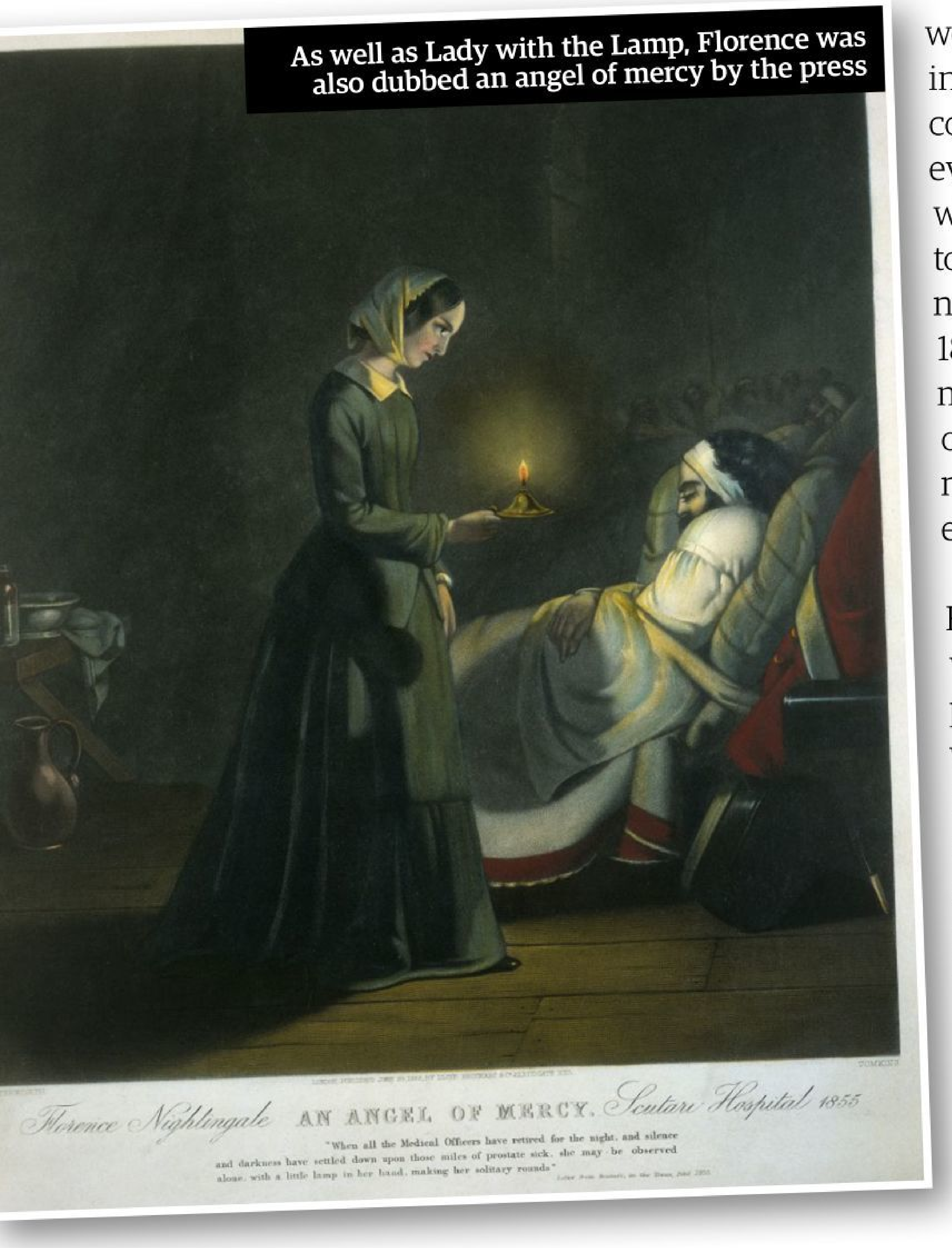
But there was an even more impoverished people Florence was determined to help – those in the workhouses. For the entirety of the workhouse system up until this point, the sick paupers were being cared for by the able-bodied paupers. Nurses in general were regarded with some disdain and were characterised as former servants and widows who had to scrape together an income. Many of these 'nurses' were not actually interested in nursing and showed little compassion. The hospitals were even worse – places of no hope where the floor was lined with straw to soak up blood. Florence introduced trained nurses into the workhouse system from the 1860s in a monumental move. The poorest and most unfortunate in society were finally being offered real medical care and attention, and this move was seen as an important step towards establishing the National Health Service.

It is hard to overstate how monumental Florence's work was in the nursing profession, which had seldom been treated with respect previously. She was an educated, upper-class woman with friends in high places and an iron will to achieve change. Many of her contemporaries commented on her stubborn, opinionated nature, but these were the essential parts of her character that ensured she saw the change she set out to achieve. This change was not only witnessed in Great Britain, but the United States was also taking notice of the Lady of the Lamp's impressive achievements. The Union government directly approached Florence for guidance and her advice inspired them to create the United States Sanitary Commission. Florence also went on to mentor Linda Richards who is today regarded as the United States' first trained nurse and she went on to establish nursing schools of her own, spreading Florence's teachings as far as Japan. By the start of the 1880s, nurses trained by Florence were matrons at the leading hospitals of the country from St Mary's Hospital to the Edinburgh Royal Infirmary, and even at Sydney Hospital in Australia.

> Although Florence returned home a heroine to many for her work, she lived under the pseudonym Ms Smith

Another of Florence's key areas of achievements was her work towards improving the health of the British Army in India. Now a firm advocate of germ theory, she insisted on the importance of uncontaminated water supplies as well as warning about the dangers of overcrowding and poor ventilation. She believed that if the conditions of the people of India improved, so would those of the army and she campaigned to improve the conditions of the country as a whole. Her hard work and statistical gathering in India led to the establishment of a Royal Commission into the Indian situation, and the public health in the country improved dramatically. The death rate in soldiers posted there plummeted from 68 in every 1,000 to 18.

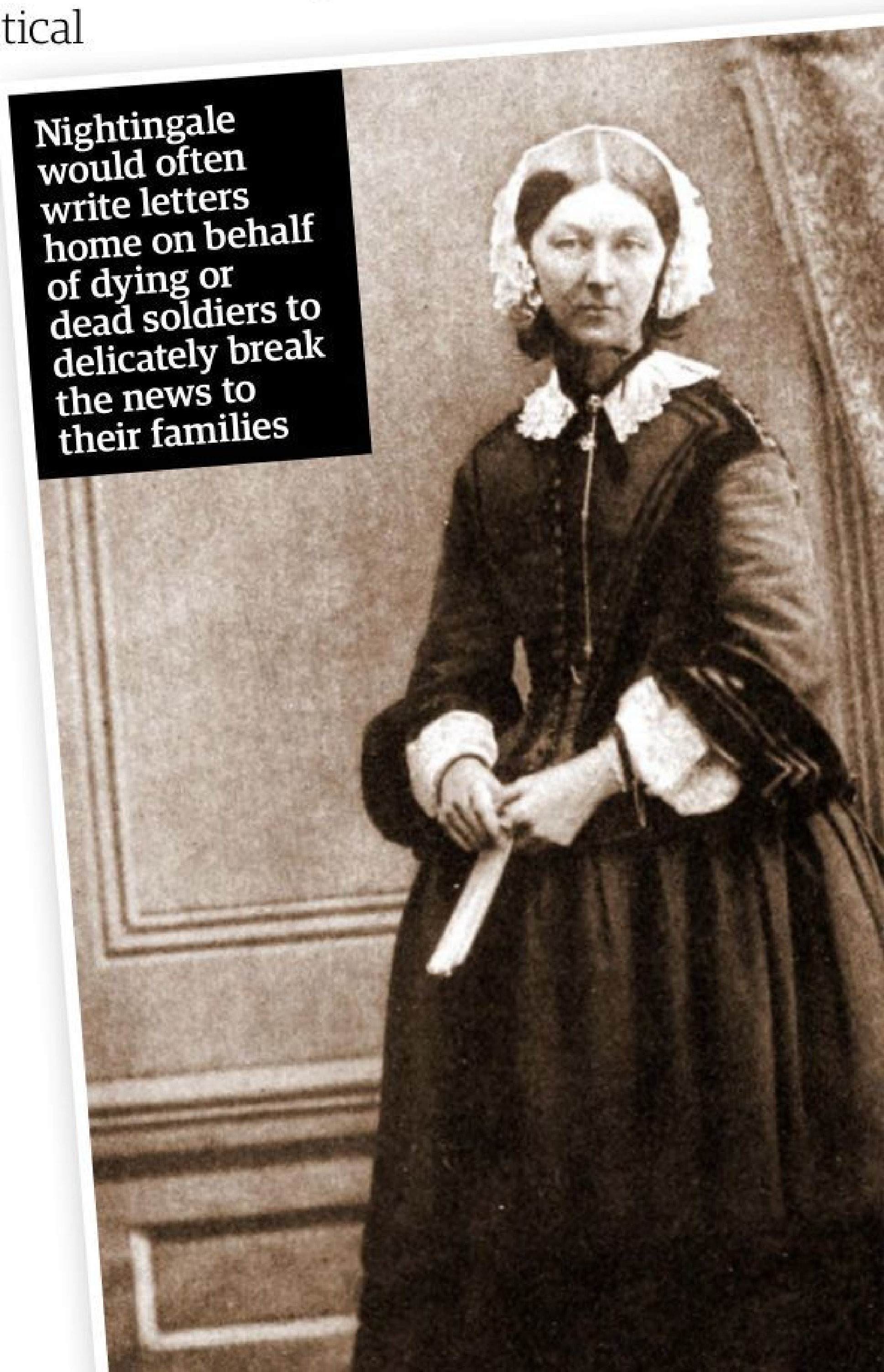
Outside of medicine, Florence also made some



As well as Lady with the Lamp, Florence was also dubbed an angel of mercy by the press

Florence Nightingale AN ANGEL OF MERCY. Scutari Hospital 1855

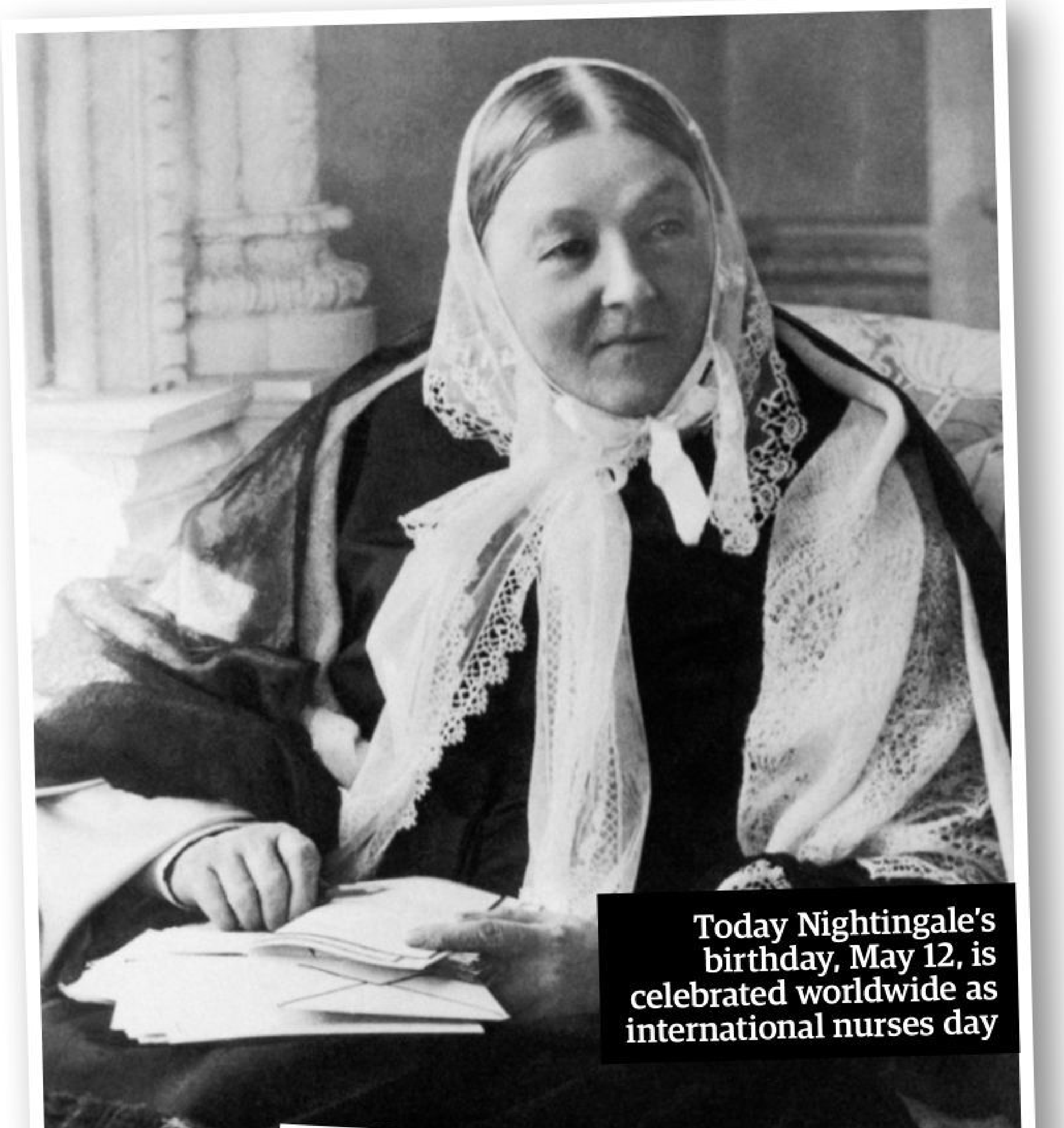
"When all the Medical Officers have retired for the night, and silence and darkness have settled down upon those miles of prostate sick, she may be observed alone, with a little lamp in her hand, making her solitary rounds."



Nightingale would often write letters home on behalf of dying or dead soldiers to delicately break the news to their families interesting contributions to theology and the role of God in her work ethic has often been examined. She believed she had been given a mission by God to dedicate her life in service to others, and she must have placed great importance upon this as she defied tradition and never married. Although she was a member of the Church of England, her views were unorthodox. She believed the purest manifestation of religion was to show kindness and care for others. She was also a firm believer that all who died, regardless of their religion or lack thereof, would be admitted to heaven. We know this as it's a belief that she used to comfort those dying in her care, saying that God was "far more merciful than any human creature ever was or can ever imagine".

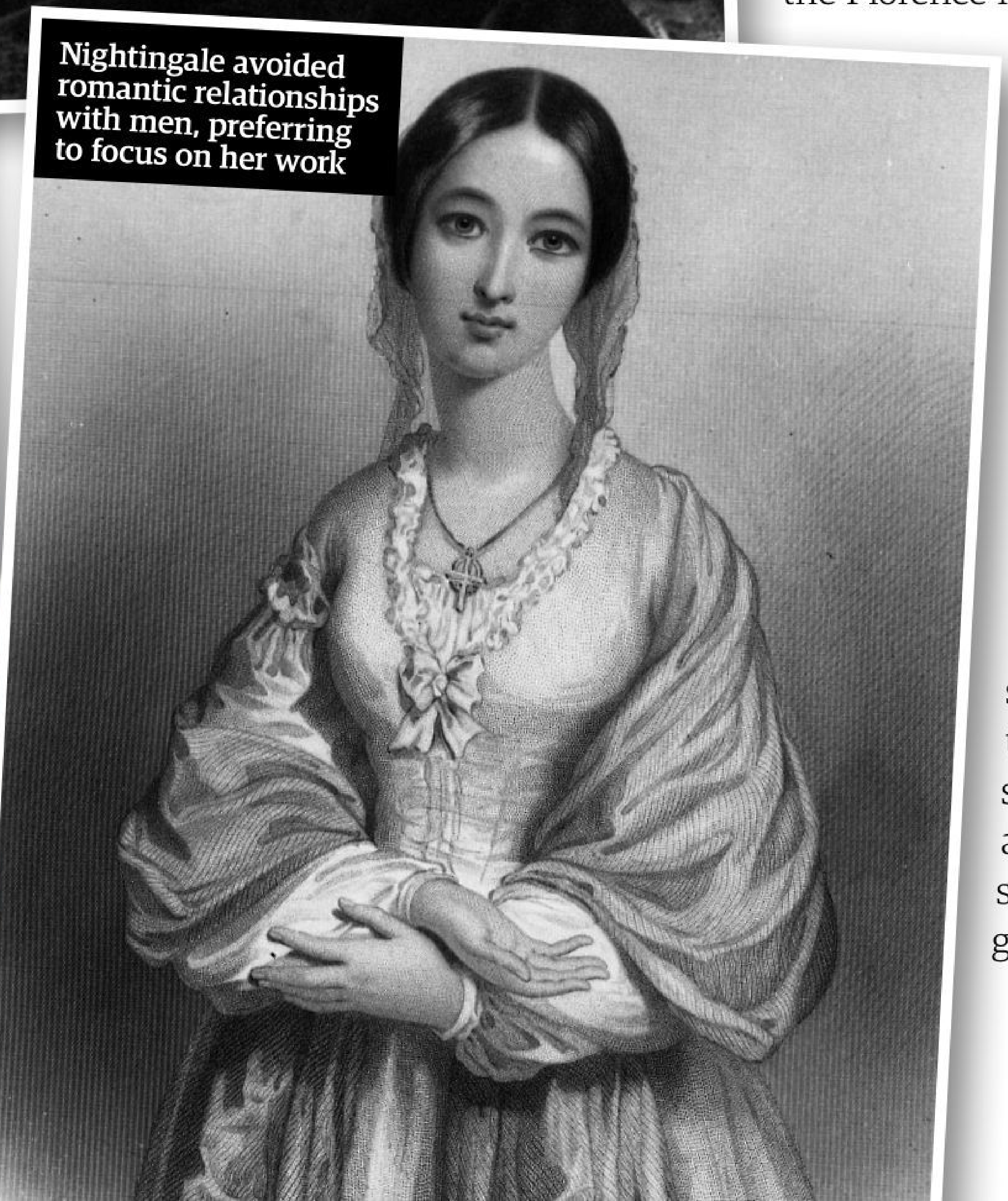
Although she was committed to Christianity, she was also a firm opponent of discrimination of non-Christian religions, believing all religions encouraged people to work hard. Her belief in the power of religion to encourage work was so strong she insisted all nurses she train attend religious services. On the other side of the coin, however, she was far from a blind believer as she criticised the Church of England for often worsening the conditions of the poor, and she even said that secular hospitals usually provided better care than religious institutions. It is clear to see by her open-minded approach that she was not afraid to take a trail-blazing, different opinion, especially for her era, and ultimately her concern was not to further her own agenda, but to ensure the least fortunate in society were provided with the care and comfort they deserved.

> "She was not afraid to take a trail-blazing, different opinion"



Today Nightingale's birthday, May 12, is celebrated worldwide as international nurses day

However, as enterprising as she was, Florence was still mortal and from 1857 onwards she was bedridden and plagued by depression due to ill health, with modern sources claiming an extreme case of brucellosis was the source of her problems. Despite her bedridden state, Nightingale remained productive, continuing to carry out pioneering work in hospital planning across the world. Her work did gradually slow in the last decade of her life as she became steadily blind and with decreased mental capabilities. On 13 August 1910, at the impressive age of 90, Florence died in her sleep at her home in Mayfair, London. Due to her immense contributions to medicine, her family received an offer to bury her at Westminster Abbey, but this was rejected. She was instead buried in the graveyard of Saint Margaret's Church in Wellow, Hampshire.



Nightingale avoided romantic relationships with men, preferring to focus on her work

Today, Florence's contribution to nursing cannot be overexaggerated. Regarded as the founder of modern nursing, she created a culture of compassion towards patients and a commitment to diligent hospital administration that continues to this day. The Florence Nightingale Medal was established in 1912 and it is regarded as the highest international distinction any nurse can achieve. Similar to the Hippocratic Oath recited by doctors, the Florence Nightingale Pledge is uttered by nurses at their pinning ceremony at the end of training. Although the words were not written by Florence herself, it was her intrepid work and commitment that formed the basis for the pledge. Countless hospitals and monuments have been erected in her name, and plays, films and televisions shows focus on her life and work. Starting life as a headstrong girl who collected shells and defied tradition, Florence is truly a testament to the intrepid human spirit. Not only did her work change the perception of nurses forever, but she urged reluctant governments to act, and in the process she helped save thousands, if not more, from gruesome, painful deaths.

NIGHTINGALE THE FEMINIST

Florence had some somewhat surprising views about women. She believed in general they were not as capable as men, and almost all of her friends were men, especially powerful ones. She believed males had done far more to help her attain her own goals than women and she even went as far to refer to herself as a "man of action".

Despite this less than flattering view, Nightingale's work did improve the situations of many women and she has become a central figure in English feminism. This is due to the immense number of works she penned and her ability to forgo the expectations of her gender to achieve her ambitions. Florence helped open up far more options for women in the workforce, expanding their horizons and offering a chance to escape a life of domestication.

Another important contribution made towards women's rights was Florence's work in abolishing overly harsh prostitution laws. Under the Contagious Diseases Act, policemen could arrest prostitutes and force them to undergo STD tests – any women found to be positive were locked in a hospital to 'protect men'. Florence campaigned to have the Act abolished and this finally happened in 1886.

In the 1920s and 30s especially, Florence was upheld as an icon for feminists across the country. Though she may not have thought particularly fondly of her own gender, her work towards bettering the lot of women everywhere cannot be ignored.

Florence's interactions with Mary Clarke influenced her views on feminism from an early age

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Marie Curie was the first woman to receive the Nobel Prize and the first to win the coveted award a second time

MARIE CURIE RADIOACTIVE FRONTIER

A pioneer in nuclear physics and chemistry, Marie Curie made bold discoveries resulting in tremendous contributions to medical science and other fields

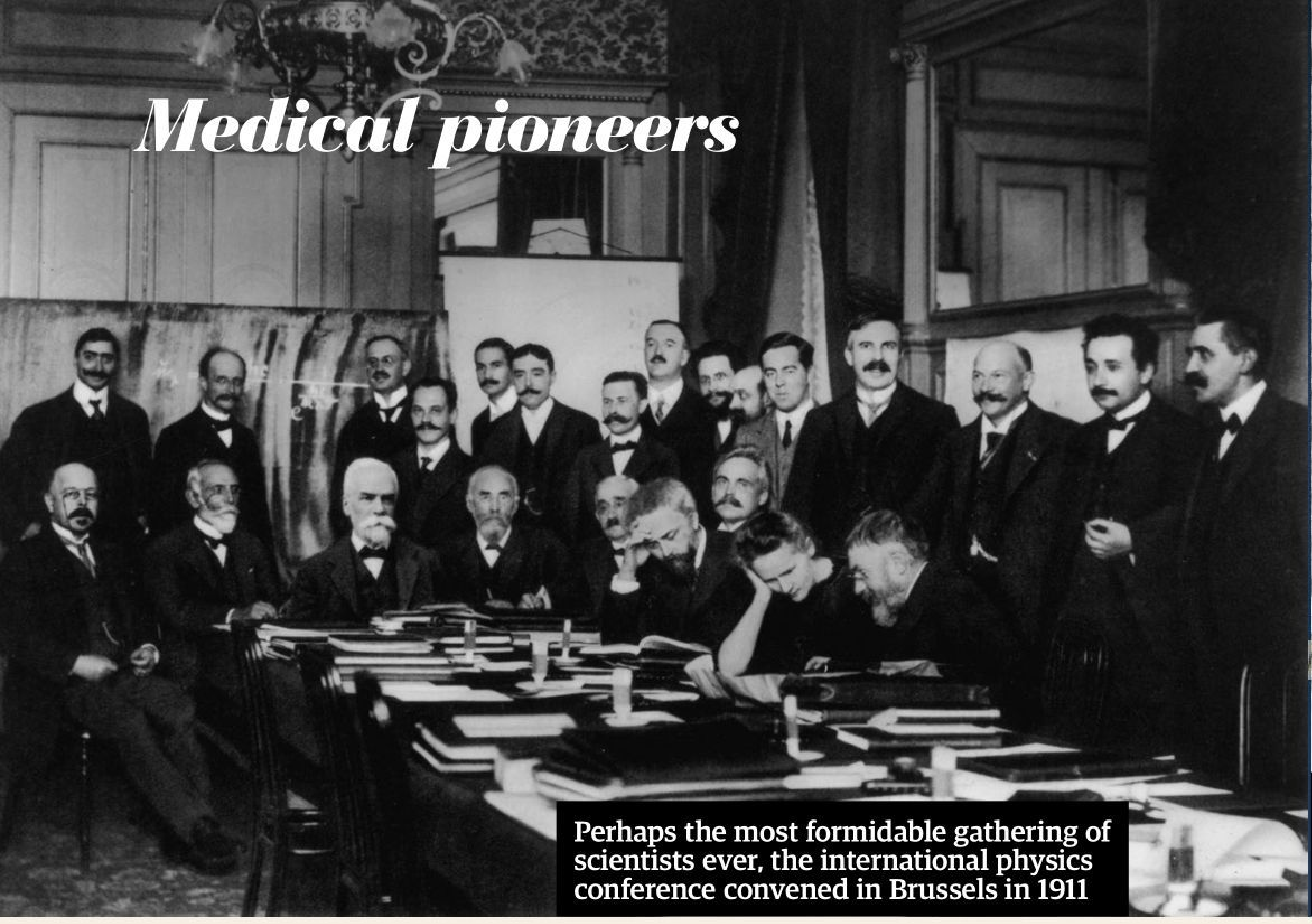
She coined the term 'radioactivity'; she was the first woman to win the Nobel Prize; and then, for good measure, she won it a second time.

Marie Curie explored the properties of radioactivity, and discovered two elements: radium and polonium. She applied her acquired knowledge to the field of medical science through the use of diagnostic X-rays and early assessments of its capacity to fight cancer. Her achievements were remarkable; however, they were even more noteworthy because she was a woman whose intellectual and scientific prowess were undeniable in a professional arena previously dominated by men.

Born in the city of Warsaw, then a part of Imperial Russia, Maria Salomea Sklodowska was the fifth and youngest child of Wladyslaw and Bronislawa Boguska Sklodowski, both well-known educators who prized the pursuit of academic excellence. Her mother died of tuberculosis when Maria was only ten years old. Polish nationalism was a hallmark of the family's world view, and the loss of property experienced during support of such movements and periodic uprisings had left them struggling financially. Maria was educated in the local school system initially, while her father, a teacher of mathematics and physics, provided additional learning opportunities, particularly after the Russian authorities restricted laboratory instruction in the schools. Wladyslaw brought his equipment home and taught his children there.

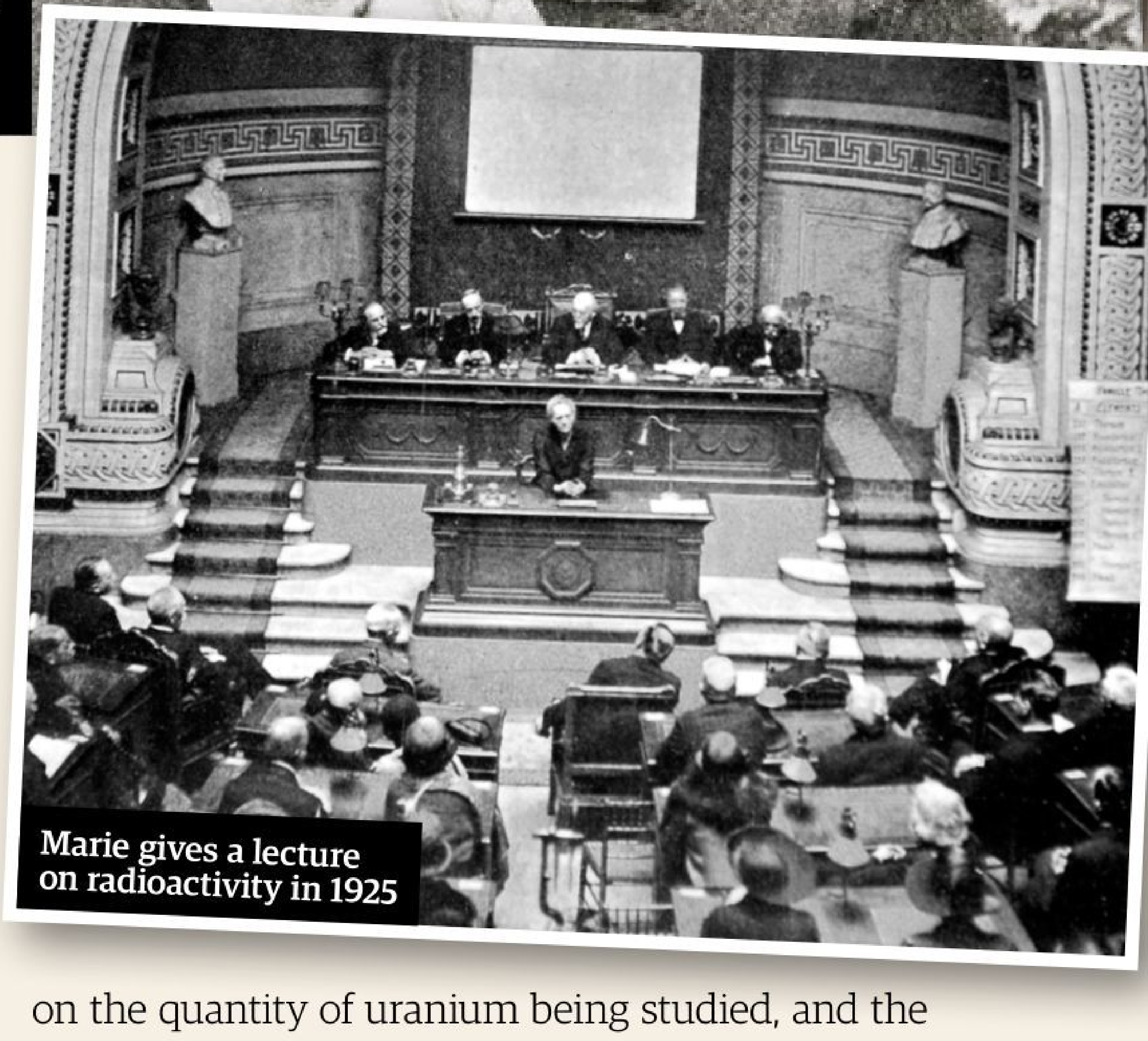
Marie Curie received two Nobel Prizes in her life, one in physics and the other in chemistry

A gifted student, Maria excelled in secondary school. However, she was prohibited from attending college because she was female. Along with her sister, Bronislawa, she enrolled in the 'Floating' or 'Flying' University, a clandestine college that conducted classes out of sight of the authorities, and also supported Polish nationalistic ideals. Prospects for higher education were more favourable to women in Western Europe, and the sisters came to an agreement: Maria would support Bronislawa while the latter obtained a degree, then the older sister would reciprocate. During the next five years, Maria worked as a tutor and a governess,



Perhaps the most formidable gathering of scientists ever, the international physics conference convened in Brussels in 1911

Marie and Pierre Curie sit with their eldest daughter, Irène, in 1902. A second daughter, Ève, was born in 1904

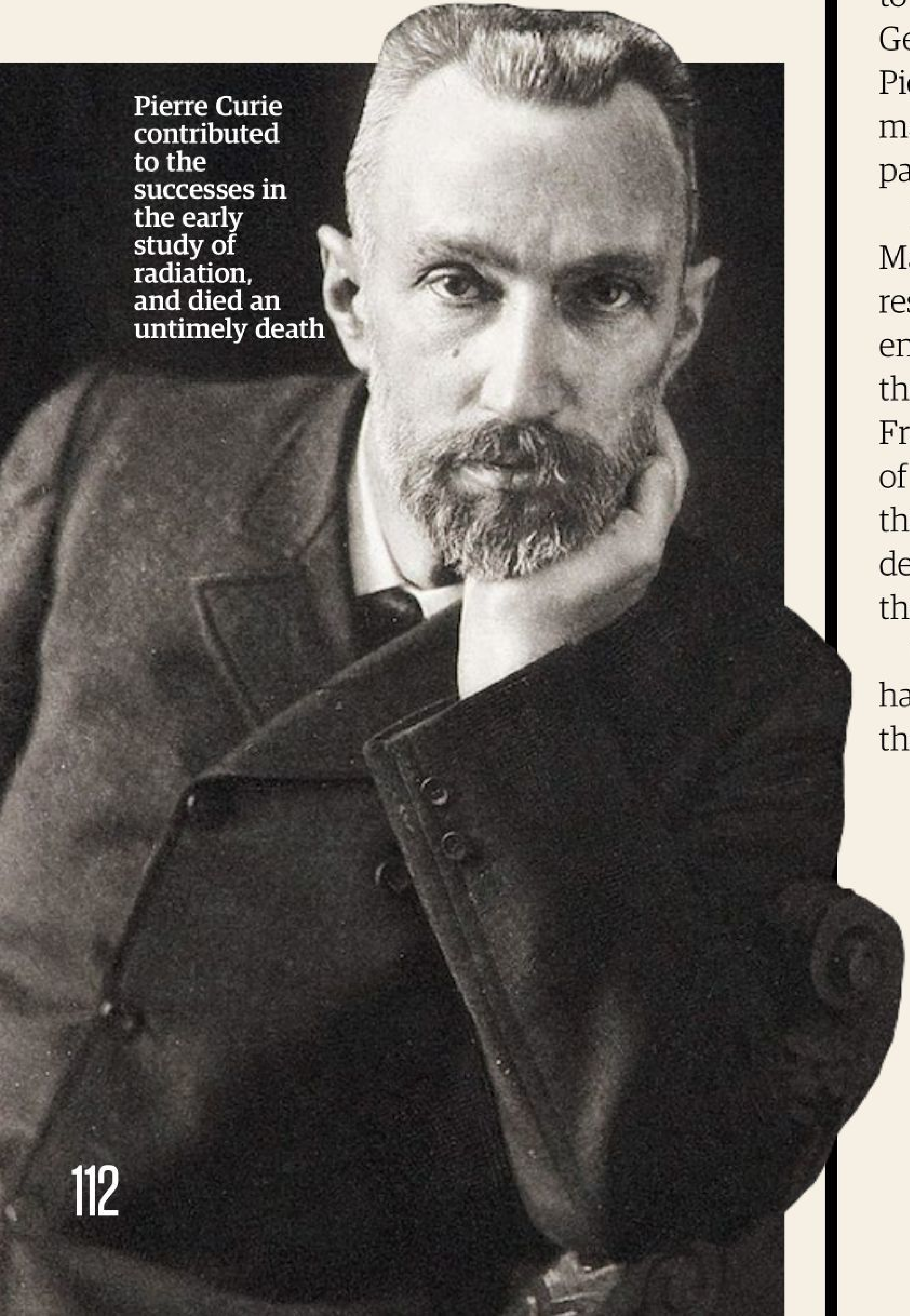


Marie gives a lecture on radioactivity in 1925

The tragic death of Pierre Curie

On a rainy 19 April 1906, Pierre Curie had just finished lunch with a few professional associates in Paris, and was walking to another appointment nearby. When he reached the intersection of the Quai des Grands Augustins with the Rue Dauphine near the Pont Neuf, he attempted to quickly cross one of the most dangerous intersections in the city. Reportedly, two police officers were stationed at the intersection at all times to direct traffic. However, if they were present on this day there was little that could have been done to prevent the tragic accident that occurred. One of the world's foremost physicists stepped into the path of a horse-drawn cart and was immediately struck, apparently falling beneath the wheels of the cart and fracturing his skull. He died swiftly.

When she received the news of her husband's death, Marie was heartbroken, but maintained her composure. Others attributed the cause of the accident, at least in part, to Pierre's carelessness and hurried pace. When his father learned of the tragedy, he responded: "What was he dreaming of this time?" A lab assistant had reportedly observed that Pierre was often inattentive while walking and riding his bicycle, "...thinking of other things".



Pierre Curie contributed to the successes in the early study of radiation, and died an untimely death

falling in love with a man but being heartbroken when the family, distantly related through Maria's father, rejected the notion of marriage.

By 1891, Maria, who would become known as Marie in France, joined her sister and brother-in-law in Paris and enrolled at the Sorbonne. She was introduced to a community of physicists and chemists who were already establishing their own preeminence in these fields. Inspired, Marie worked tirelessly to obtain licensing in physical sciences and mathematics, and assisting in the laboratory of physicist and inventor Gabriel Lippmann, a future Nobel laureate. The long hours took their toll on Marie's health, as she subsisted primarily on tea, bread and butter. Within three years, though, she had achieved her immediate goals.

By 1894, Marie had secured a commission from the Society for the Encouragement of National Industry for research on the magnetic properties exhibited by numerous types of steel. Supposedly she needed a laboratory to work in, and was introduced to Pierre Curie by fellow physicist Józef Wierusz-Kowalski. Pierre made room in his living space, and a romance developed, but Marie returned to Poland that summer to visit her family, and hoped to gain a teaching position at Kraków University. Gender discrimination again stood in her way, and Pierre persuaded her to return to Paris. The couple married on 26 July 1895, and a pivotal scientific partnership was poised for great achievement.

During this golden age of rapid scientific discovery, Marie searched for a worthy topic for further research, and the production of a thesis. German engineer and physicist Wilhelm Röntgen discovered the presence of X-rays in 1895, and the following year French physicist Henri Becquerel detected emissions of similar rays while researching uranium. News of the discoveries intrigued Marie. The rays did not depend on an external energy source. Apparently, they were produced within the uranium itself.

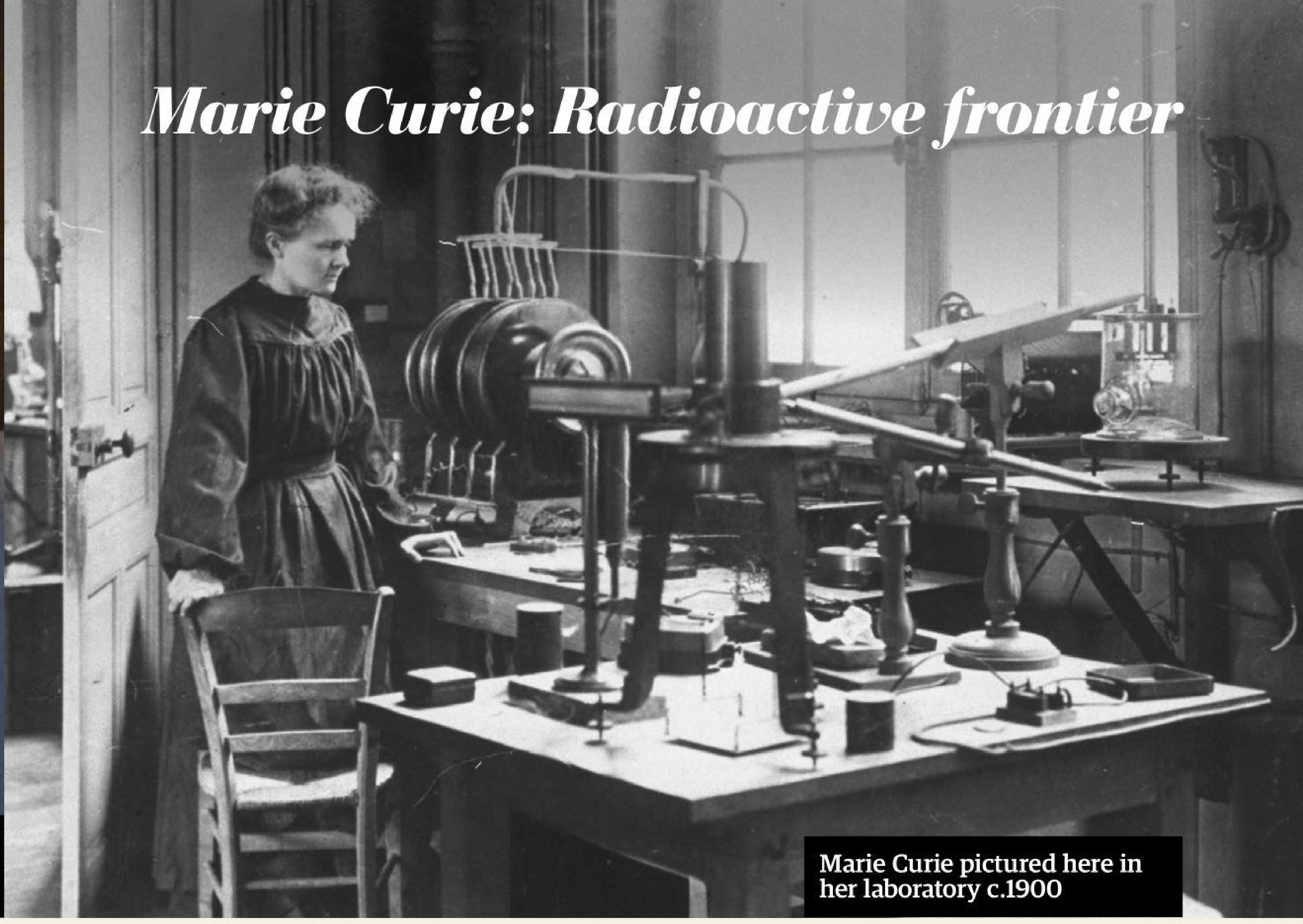
Using a spectrometer that Pierre and his brother had developed 15 years earlier, Marie determined that the level of activity present was solely dependent on the quantity of uranium being studied, and the activity remained constant regardless of the form of the element. She concluded that the energy was a product of the atomic structure of uranium rather than interaction between molecules, giving rise to the field of atomic physics.

Marie named the newly discovered form of energy 'radioactivity', and began researching other minerals that exhibited similar properties. She found that the mineral pitchblende, now known as uraninite, was ideal for continued research. Pierre discontinued his work on other projects and joined Marie. In the summer of 1898, the husband and wife team discovered the element polonium, which Marie named after her homeland of Poland. Later that year, they discovered a second element and called it radium. Pierre concentrated on the physical properties of radioactivity, while Marie worked to isolate radium in its metallic state.

Meanwhile, the Curies and Becquerel were jointly awarded the Nobel Prize in Physics in December 1903, in recognition of their collective research on 'the radiation phenomena' discovered by Becquerel. Although the initial nomination was intended for Pierre Curie and Becquerel only, Pierre's complaint to the Royal Swedish Academy of Sciences resulted in the addition of Marie to the award as the first woman to receive the Nobel Prize. The Curies also

> "The couple married on 26 July 1895, and a pivotal scientific partnership was poised for great achievement"

The tombs of Marie and Pierre Curie now lie in the Panthéon in Paris, where other great French scientists and personages are interred



Marie Curie pictured here in her laboratory c.1900

received the prestigious Davy Medal from the Royal Society of London that year.

In 1906, Pierre was killed in an accident on a Paris street. Marie was devastated, but pursued her research with renewed vigour, succeeding her late husband as chair of the physics department at the University of Paris. Four years later, she successfully isolated radium as a pure metal. Even as her personal life became embroiled in scandal during a period of French xenophobia because of her foreign birth, right-wing criticism of her apparent atheistic perspective on religion, and speculation that she was Jewish amid a rising tide of anti-Semitism, her scientific contributions were undeniable. In 1911, it was revealed that she had been involved in an affair with a former student of her husband who was separated from his wife. Nevertheless, in that same year she received the Nobel Prize in Chemistry for the discovery of polonium and radium and the isolation of radium.

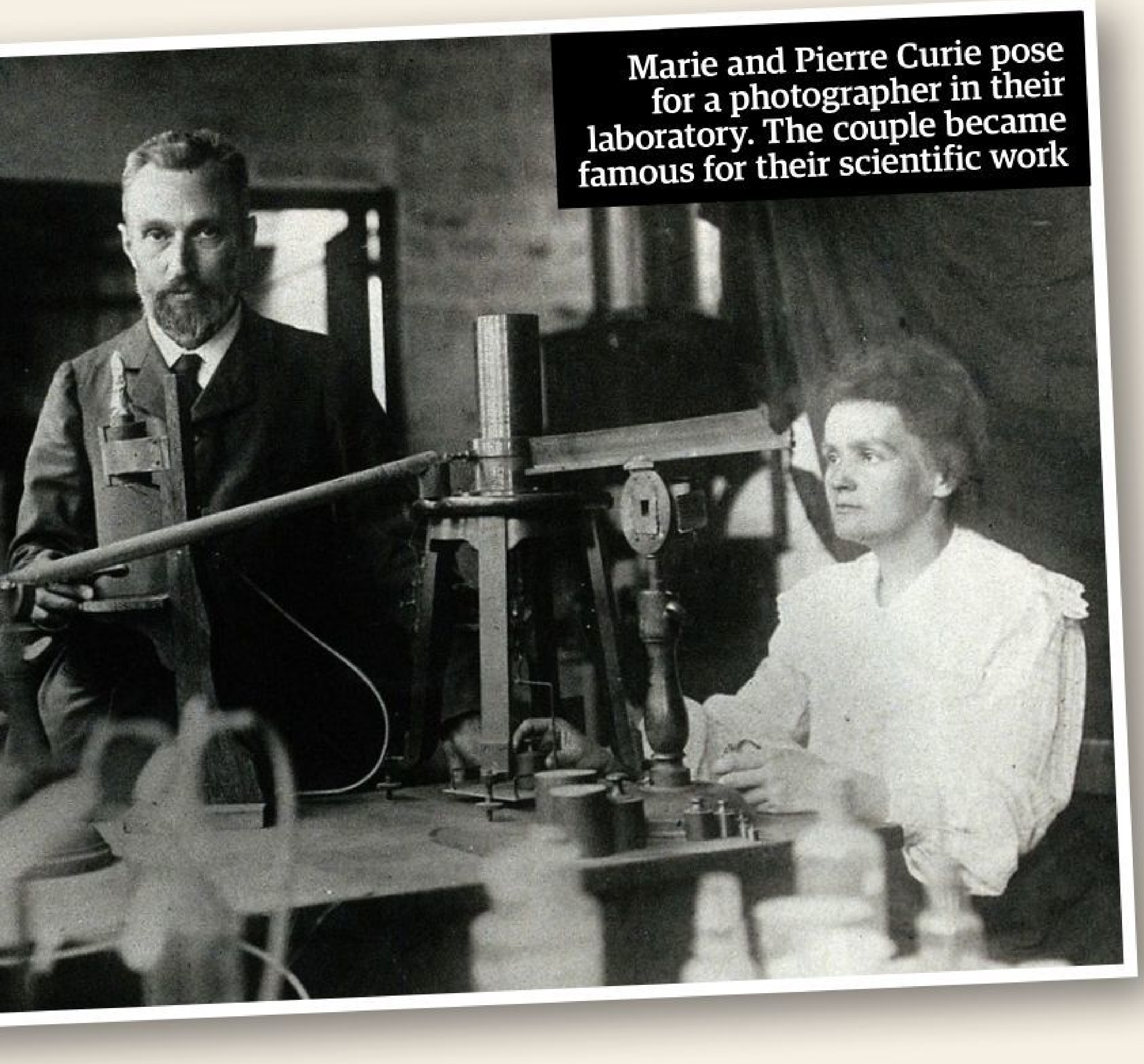
As the first person to receive the Nobel Prize twice, and to be so recognised in two separate fields, Marie Curie's prestige made a convincing argument for government support of the establishment of the Radium Institute in 1914 at the University of Paris, which continues today as a leading research institution in medicine, chemistry and physics. With the outbreak of World War I, she worked to establish mobile X-ray units using equipment adapted to automotive chassis. Eventually, 20 of these were completed. With the help of her daughter, Irène, the mobile units dubbed 'Little Curies' saved many lives with their proximity to the battlefield.

After the war, Marie continued her research in radioactive materials and chemistry. In 1921, she travelled to America to raise funds for the Radium Institute. She was hailed upon arrival in New York City, and attended a luncheon at the home of Mrs Andrew Carnegie and receptions at the Waldorf Astoria hotel and Carnegie Hall. In Washington, DC, President Warren G Harding presented her with a gram of radium and praised her "great attainments in the realms of science and intellect."

Marie gave lectures and became a member of the International Commission on Intellectual Cooperation under the auspices of the League of Nations. She authored a biography of her late husband, and in 1925 returned to her homeland to assist with the establishment of the Radium Institute in Warsaw. She travelled to the US again in 1929, successfully raising funds to equip the new laboratory, which opened in 1932 with her sister, Bronislawa, as its first director. Prior to the development of the particle accelerator in the 1930s, continuing atomic research depended upon the availability of radioactive materials. Marie realised the importance of maintaining adequate stockpiles, and her advocacy facilitated discoveries by Irène and her husband, Frédéric Joliot-Curie.

Years of prolonged exposure to radioactive materials took their toll on Marie's health. Little was known of the effects of radiation exposure – she would carry test tubes of radioactive material in the pockets of her dress, and store them in her desk drawer. She was said to have commented on the soft glow emitted from the tubes, but never realised their potential lethality. During World War I, she had also been exposed to radiation while operating X-ray equipment. As early as 1912 she had been temporarily incapacitated with depression and undergone surgery for a kidney ailment. As a result of radiation exposure, she developed leukaemia and died in Paris at the age of 66 on 4 July 1934. She was buried beside her husband.

Marie Curie remains a towering figure in the fields of physics and chemistry. Her ground-breaking achievements were also empowering for succeeding generations of women.



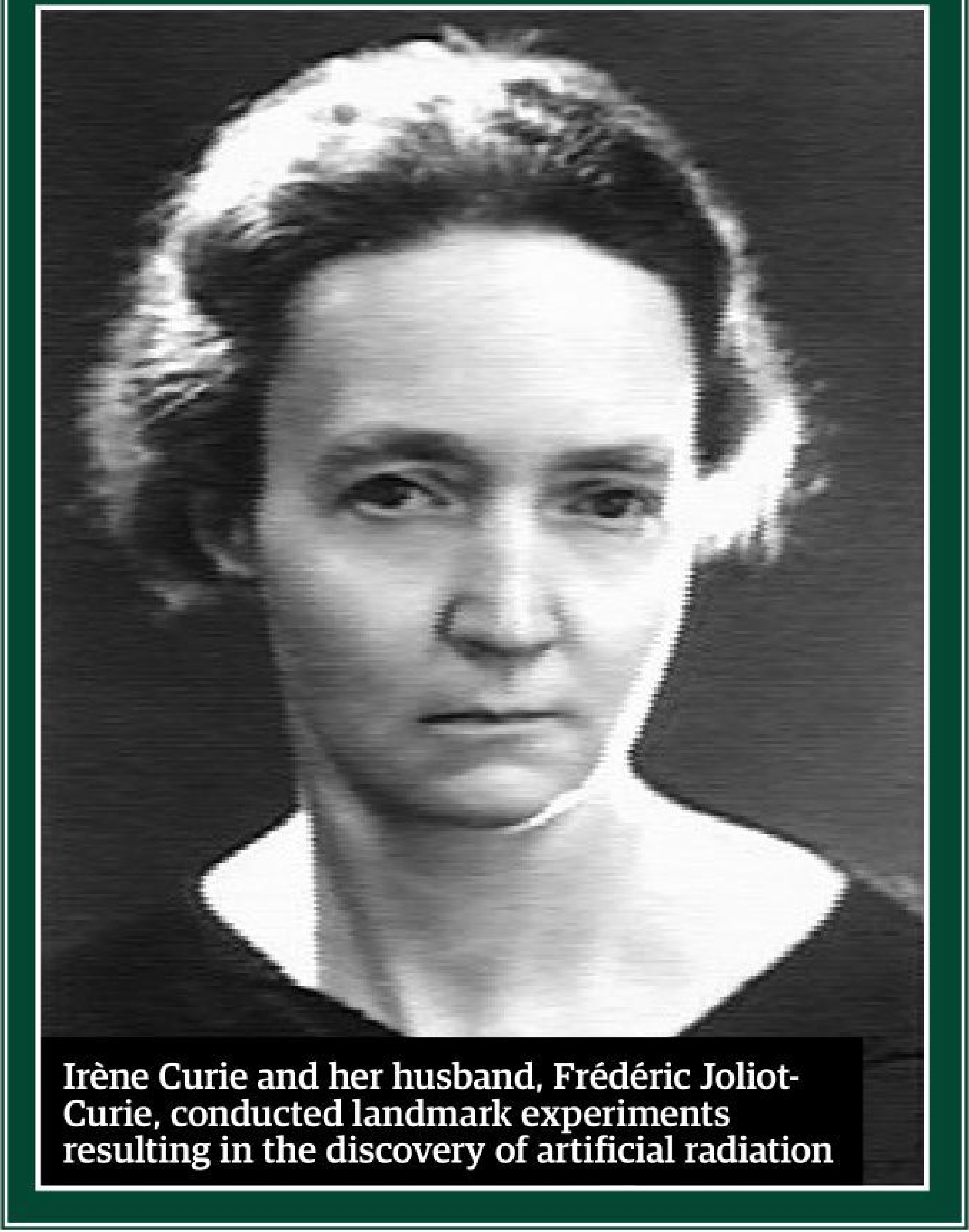
Marie and Pierre Curie pose for a photographer in their laboratory. The couple became famous for their scientific work

A DAUGHTER'S CONTRIBUTION

Irène Joliot-Curie, the oldest of two daughters of Pierre and Marie Curie, was an eminent scientist in her own right. Along with her husband, Frédéric Joliot-Curie, she received the 1935 Nobel Prize in Chemistry for her research into the properties of the atom.

The couple's greatest discovery resulted from the exposure of previously stable material to radiation, which in turn caused the material itself to become radioactive. The scientists made the discovery after bombarding a thin strip of aluminium with alpha particles, in this case helium atom nuclei. When the external source of radiation was removed, the aluminium continued to emit radiation because the aluminium atoms had been converted to an isotope of phosphorus. The discovery of artificial radiation served as a catalyst for further research into radiochemistry and the application of isotopes in medical therapies, and largely replaced the costly process of extracting radioactive isotopes from ore. The work of Irène and Frédéric also contributed to the discovery of the process of nuclear fission.

In later years, Irène became the director of the Radium Institute in Paris, and both were leaders in the development of atomic energy in France. She died of leukaemia in 1956 after years of exposure to radiation.



Irène Curie and her husband, Frédéric Joliot-Curie, conducted landmark experiments resulting in the discovery of artificial radiation

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THE CURIE LABORATORY

C. 1904

This detailed engraving shows the laboratory that Marie Curie shared with her husband, Pierre. The space in Paris was known to be where the Curie's carried out many of their experiments in chemistry. It was after her meeting with Pierre, an instructor at the School of Physics and Chemistry in Paris, that he was able to find an area for Marie to begin her work.

© Getty Images

ALEXANDER FLEMING

INVENTOR OF THE WONDER DRUG

The discovery of penicillin by Alexander Fleming led to the development of the world's first antibiotics, saving countless lives

Alexander Fleming: Inventor of the wonder drug

An unkempt office, an uncovered petri dish, an errant mould spore and possibly an open window – these were some of the haphazard events that led to the discovery of perhaps the greatest wonder drug the world has ever seen.

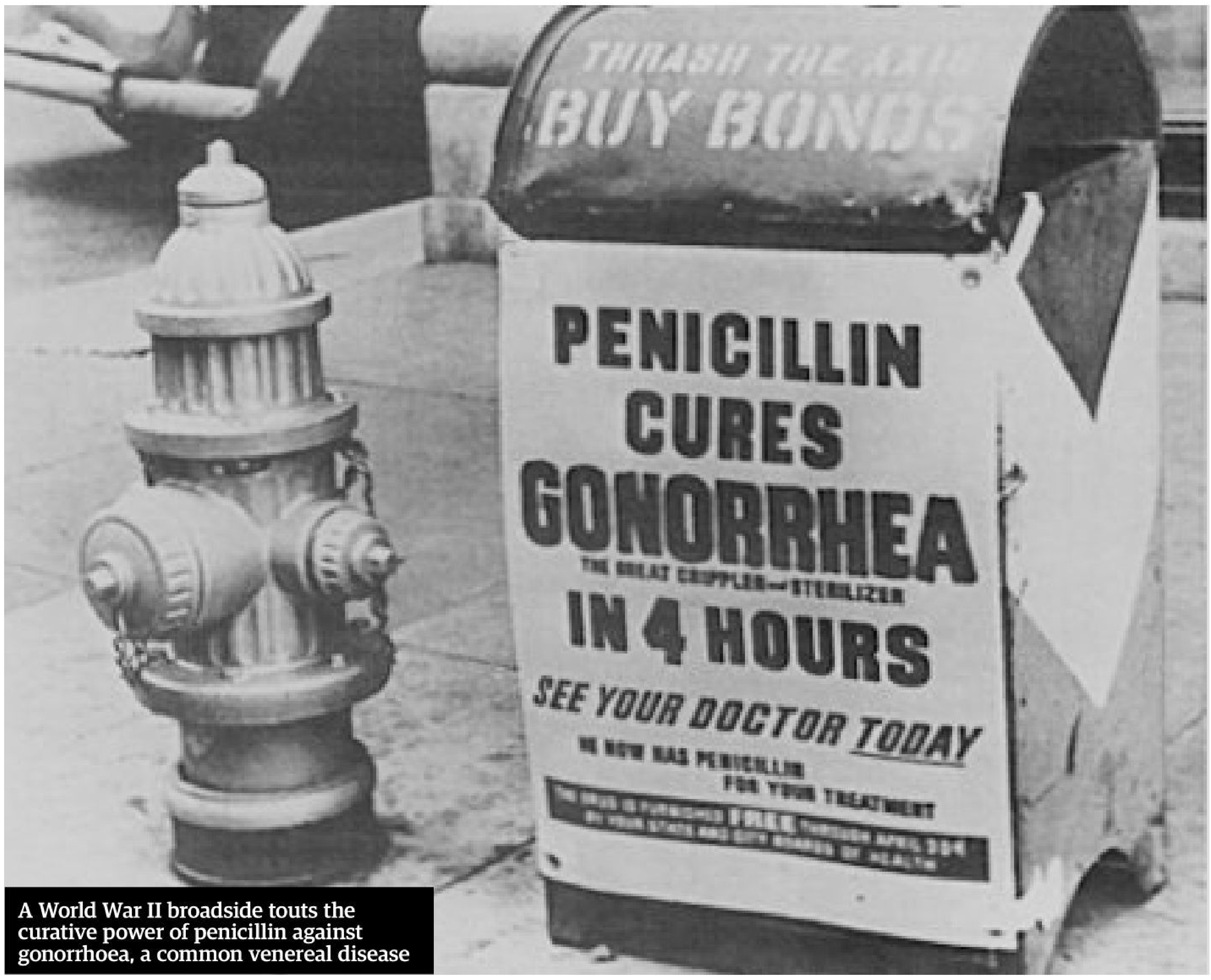
"One sometimes finds what one is not looking for. When I woke up just after dawn on 28 September 1928, I certainly didn't plan to revolutionise all medicine by discovering the world's first antibiotic, or bacteria killer. But I guess that was exactly what I did," commented Alexander Fleming on his discovery of penicillin. The eventual result of the discovery, however, has profoundly affected the world in which we live. Millions of individuals suffering from once debilitating or lethal bacterial infections such as pneumonia, gonorrhea, diphtheria, and meningitis have been cured – to live, work, and make their own discoveries and contributions.

As discoveries sometimes are, the revelation of the curative power of Penicillium notatum was completely unexpected. Fleming said that it "was a triumph of accident, a fortunate occurrence which happened while I was working on a purely academic bacteriological problem."

At the time of his discovery, Fleming was a 47-year-old microbiologist and physician, born on 6 August 1881, at Lochfield Farm near the town of Darvel in Ayrshire, Scotland. He was the third of four children of farmers Hugh Fleming and Grace Stirling Morton Fleming. Hugh was 59 when Alexander was born and died seven years later. After attending primary school near his home, young Alexander moved to London in 1895 and lived with his older brother, Thomas, finishing his basic education at the Regent Street Polytechnic, now the University of Westminster. During the next four years, he worked in a shipping office and served briefly in the Boer War, although he was never in combat.

During this period, Fleming's uncle, John, died, and his will provided for the distribution of his estate among relatives. Thomas was already a physician, and Alexander used a portion of his inheritance to pursue a medical career, enrolling in St Mary's Hospital Medical School in Paddington in 1903. He graduated with honours in 1906. Since 1900, Alexander had served as a private in the London Scottish Regiment of the Territorial Army

Sir Alexander Fleming is credited with the accidental discovery of penicillin in 1928, leading to the introduction of antibiotic therapy



A World War II broadside touts the curative power of penicillin against gonorrhoea, a common venereal disease

and developed a reputation as a crack shot with a rifle. At St Mary's he had become a member of the rifle club's competition team. The captain of the team, rather than seeing one of his best performers drift away, encouraged Fleming to secure a position in the Inoculation Department as a medical bacteriologist under Sir Almroth Wright, a leading figure in vaccine therapy.

Fleming continued his studies in bacteriology, earning additional degrees, receiving the gold medal as the highest performing medical student at the university in 1908, and serving as a lecturer at St Mary's until the outbreak of World War I in 1914. Wright, a proponent of the ability of the body's own immune system to fight disease rather than dependence on 'chemotherapy,' or the introduction of a foreign substance to assist in the battle, assigned Fleming to work with a new drug called Salvarsan developed by German researcher Paul Ehrlich and his Japanese colleague Sahachiro Hata to cure syphilis. Fleming took samples and treated patients by intravenous injection, achieving positive results. For a time, he maintained a profitable practice treating well-to-do patients who had contracted the venereal disease.

With the outbreak of the Great War, Fleming followed Wright to France as an officer in the Royal Army Medical Corps. Rising to the rank of captain, he worked in a specialised wound research laboratory in the coastal city of Boulogne.

He was mentioned in dispatches for bravery and service, while continuing to hone his research skills. Observing the treatment of wounded soldiers, he became alarmed that many of them seemed to be dying from infections that were being treated with antiseptics such as carbolic acid.

Fleming's curiosity piqued, he remembered, "Surrounded by all these infected wounds, by men who were suffering and dying without our being able to do anything to help them, I was consumed by a desire to discover, after all the struggling and waiting, something which would kill those microbes."

Apparently, the antiseptic was killing germs on the surface and just below the skin, but in deep wounds anaerobic bacteria, which did not need free oxygen to survive, were isolated from it. Simultaneously, the antiseptics in use did not discriminate harmful bacteria from those agents that were useful and produced by the body's immune system, killing both. The continued presence of the anaerobic bacteria fostered deadly infection and caused the mortality rate among wounded patients to soar. Fleming asserted that antiseptics failed to sterilise deep wounds and proved with cells on a microscope slide that they

In 1944, Fleming was knighted by King George VI for all of his achievements in the field of science

> "Fleming asserted that antiseptics failed to sterilise deep wounds"

FLOREY FUELLED ANTIBIOTIC STUDIES

While Alexander Fleming sought scientists with a chemistry background to take up the challenges with penicillin, Australian-born Howard Florey and his German émigré cohort Ernst Chain had begun to explore the potential of antibacterial substances, particularly the enzyme lysozyme, in the early 1920s. Florey and Chain became aware of penicillin and shifted their attention to its antibiotic properties.

In 1938, with a grant from the Rockefeller Foundation, the two succeeded in devising a method for the manufacture of penicillin in limited quantities. Along with Norman Heatley and Edward Abraham, their work persuaded major pharmaceutical manufacturers to produce the lifesaving antibiotic on an industrial scale. Years later, Sir Henry Harris, an Oxford physician who had studied under Florey, remarked, "Without Fleming, no Chain; without Chain, no Florey; without Florey, no Heatley; without Heatley, no penicillin."

Nobel laureate Florey received many other accolades during his career and once noted that scientific curiosity rather than concern for human suffering had driven his team's research in the beginning. "I don't think it ever crossed our minds about suffering humanity," he wrote. "This was an interesting scientific exercise, and because it was of some use in medicine is very gratifying, but this was not the reason that we started working on it." He died in 1968 at the age of 69.

Australian Prime Minister Robert Menzies called Howard Florey "in terms of world well-being... the most important man ever born in Australia"

Celebrated biochemist Edward Abraham worked on the development of penicillin at the University of Oxford and later the antibiotic cephalosporin

German biochemist Ernst Chain was a leader of the Oxford team that transformed penicillin from a curiosity into a miracle drug

The will of Swedish scientist Alfred Nobel established prizes in numerous fields in 1895, including physiology or medicine

actually damaged the body's white blood cells while having no appreciable effect on anaerobic disease-causing bacteria. Despite his research and written documentation along with Wright's favourable review, doctors on the Western Front in World War I went on administering antiseptics.

After the war, Fleming continued his work on the immune system and white blood cells, or leukocytes. He also became the assistant director of the Inoculation Department at St Mary's. In 1921, he discovered a mild antibacterial substance in bodily fluids and tissues such as tears, mucus, blood, saliva, hair, and nails, as well as milk and other liquids. He named the antiseptic enzyme lysozyme. Accounts of this important discovery vary. Some say that he was treating a patient with a severe cold and analysed the patient's nasal mucus. Others relate that he actually was the cold sufferer and that a drop of his own mucus fell from his runny nose onto a bacterial culture and prompted investigation. Fleming combined the mucus with the culture and observed within a few weeks that the bacteria had dissolved.

Penicillin changed the way that diseases were treated and cement Fleming's name in the history books

While it appeared effective against harmless microbes, lysozyme seemed to have little influence on virulent bacteria. Fleming produced larger amounts of lysozyme from egg whites, but his attempts to concentrate the enzyme and increase its effectiveness resulted in failure. Nevertheless, the discovery of lysozyme signalled progress in understanding the properties of the human immune system.

By 1927, Alexander Fleming had become a professor of bacteriology at the University of London. He was already a fellow and Hunterian professor of the Royal College of Surgeons. That year, he had undertaken a study of the staphylococcus bacteria, a common pathogen that causes boils, throat discomfort, and potentially lethal infections. In August 1928, Fleming departed his laboratory for a month-long vacation with his wife, Sarah (nicknamed Sareen), and young son, Robert. He left his workspace in its usually jumbled state. Rather than placing his staphylococcus cultures in an incubator or securing them further, he left them stacked on a bench in a corner of the laboratory. One of them was contaminated during preparation by a mould spore that had come through an open window or possibly escaped a culture from the laboratory a floor below, become airborne, and floated upstairs.

Upon his return, Fleming noticed the contaminated culture. Curiously, both mould and bacteria had grown in the ambient temperature with one notable exception. The staphylococcus colonies in close proximity to the mould had been destroyed. He isolated the mould and identified it as Penicillium notatum. Although Fleming's laboratory notes lack detail and his recollections of the immediate circumstances of the discovery were somewhat contradictory, he further concluded that, rather than the activity of another enzyme such as lysozyme, the mould had produced an antibiotic fluid, which he dubbed "mould juice". On 7 March 1929, it was named penicillin.

Fleming probed the properties of penicillin, experiencing challenges in producing enough of the antibiotic for substantive clinical trials and

Sharing the Nobel Prize

In presenting the 1945 Nobel Prize in Medicine or Physiology to Sir Alexander Fleming, Sir Howard Walter Florey, and Ernst Boris Chain, on 10 December 1945, Professor Göran Liljestrand of the staff of professors of the Royal Caroline Institute remarked, "To overcome the numerous obstacles, this work demanded not only assistance from many different quarters, but also an unusual amount of scientific enthusiasm, and a firm belief in an idea. In a time when annihilation and destruction through the inventions of man have been greater than ever before, the introduction of penicillin is a brilliant demonstration that human genius is just as well able to save life and combat disease."

At the dawn of the Atomic Age, humans had a reason to celebrate the real possibilities of a drug that might hold at bay the spectre of unnecessary death from infectious bacterial diseases. The discovery, development, and preparation of penicillin for widespread use as a therapeutic treatment was indeed a team effort. In addition to Fleming, Florey, and Chain, an army of laboratory workers took part in the process. However, Norman Heatley and Edward Abraham, both of whom had worked to purify and develop sufficient quantities of the antibiotic for testing, were left out.

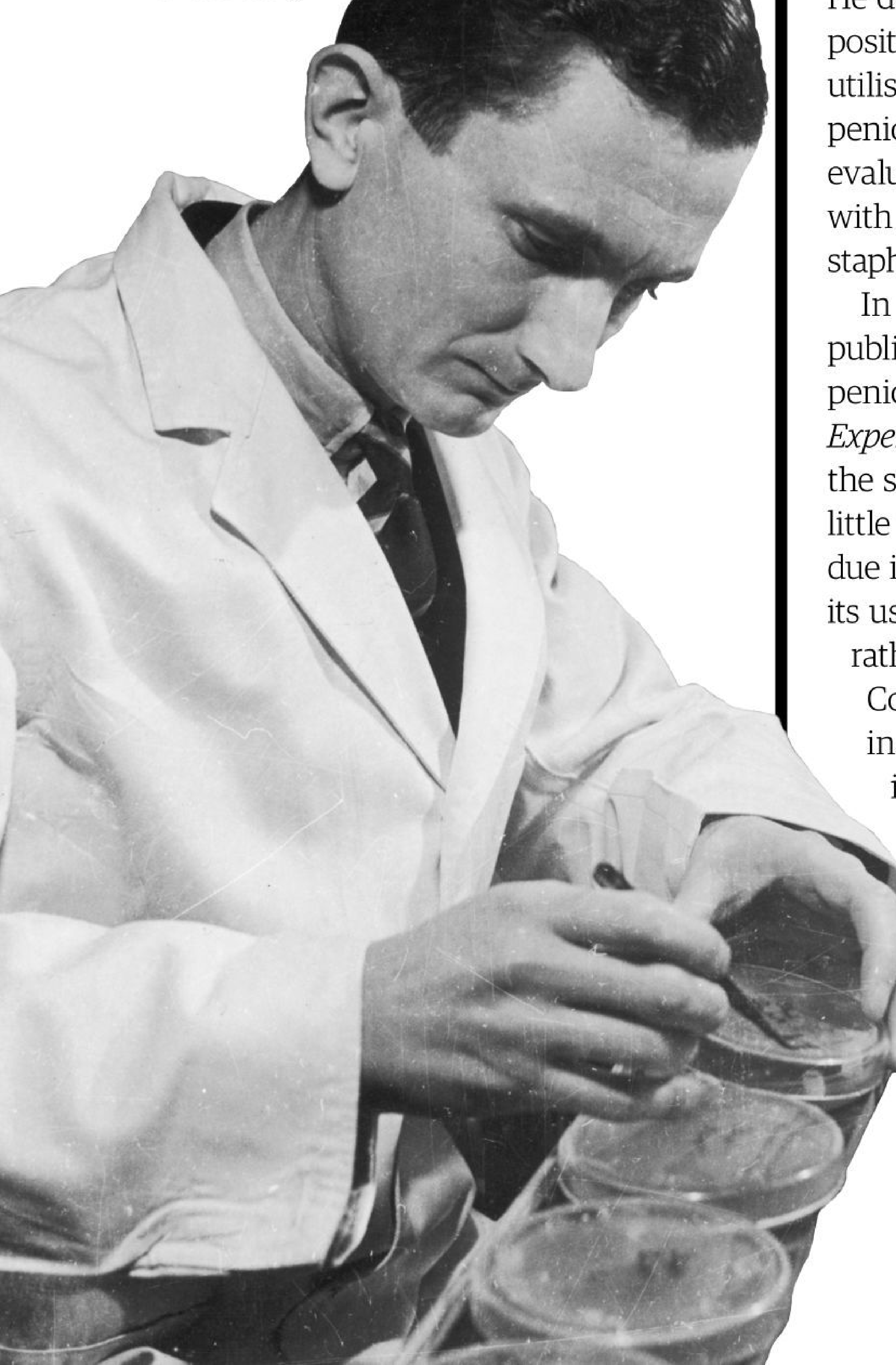
Alexander Fleming spent many years as a student, lecturer and researcher at St Mary's Hospital, Paddington

Heatley's helping hand

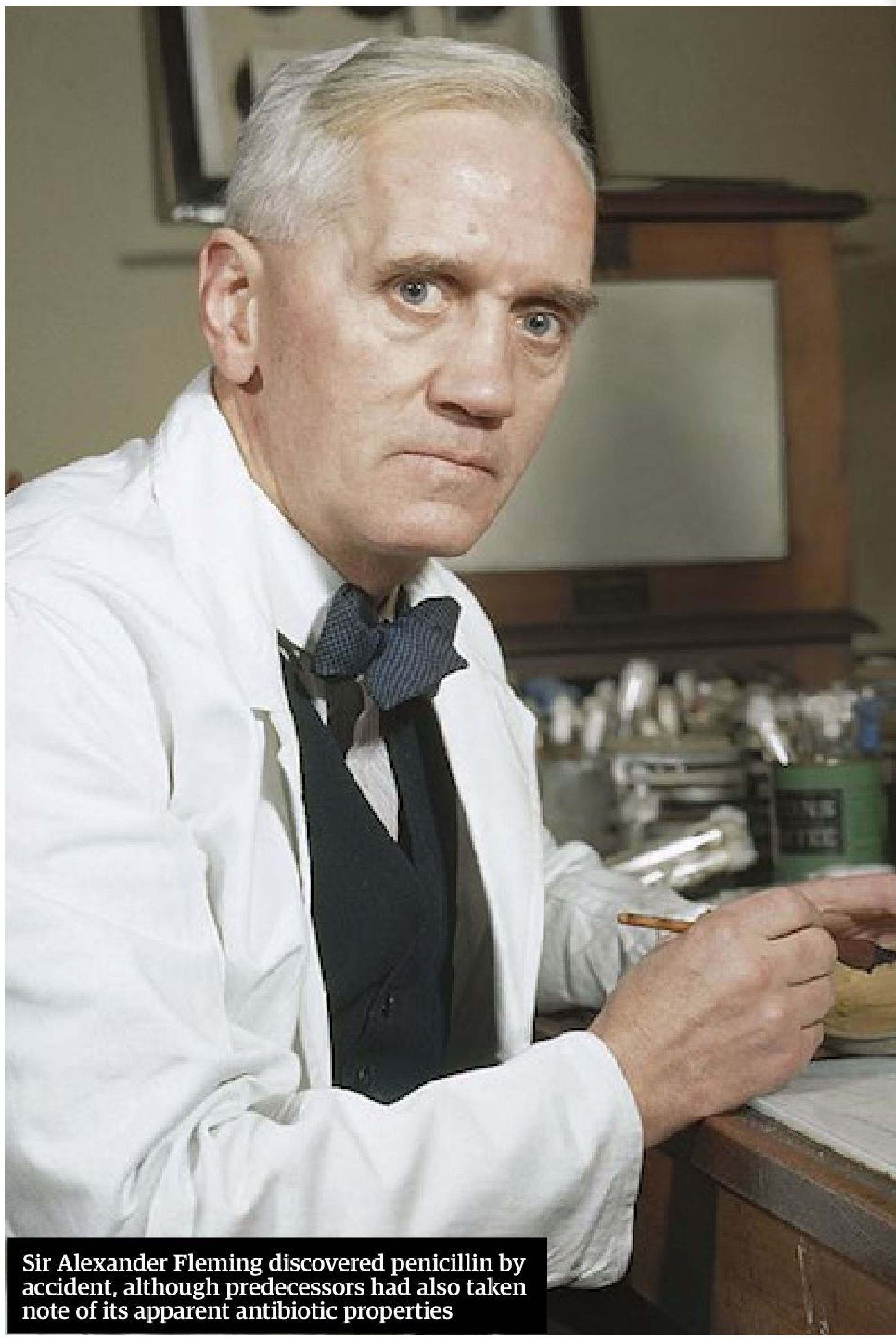
Norman Heatley, a key member of the Oxford scientific team that brought the wonder drug penicillin into mass production, making it feasible to treat bacterial infections in patients on a tremendous scale, is credited with developing the back extraction technique of purifying penicillin in bulk. Heatley was a subordinate member of the team, but when faced with the issue of extracting the antibiotic in quantity he suggested that the active material should be transferred to water to change its acidity prior to re-extraction. The process worked.

Heatley resorted to using specially made 'bedpans' as he turned the Oxford laboratory into a small penicillin factory, enabling his colleagues to conduct the first clinical trials on laboratory animals. Heatley also travelled to the United States with Howard Florey in search of a manufacturer that would agree to produce at least a kilogram of penicillin. They succeeded after discussions with the management of a Peoria, Illinois, facility.

Heatley's contribution to the penicillin 'miracle' went largely unrecognised for the next half century. However, in 1990 the biochemist and biologist received an honorary doctorate in medicine from Oxford University, the first given to a non-medical individual in Oxford's 800-year history. Heatley died in 2004 at the age of 92.



Norman Heatley, a prominent participant in the development of viable penicillin for therapeutic use, works in his laboratory



Sir Alexander Fleming discovered penicillin by accident, although predecessors had also taken note of its apparent antibiotic properties

During his lifetime, Alexander Fleming received many awards, including a share of the 1945 Nobel Prize for Medicine or Physiology

even in concentrating and stabilising the agent. He determined it was effective primarily on Gram-positive bacteria, in reference to a testing method utilising dyes. He exposed a rabbit and a mouse to penicillin to determine their tolerance but did not evaluate its curative potential by experimenting with laboratory animals infected with staphylococcus or other microbes.

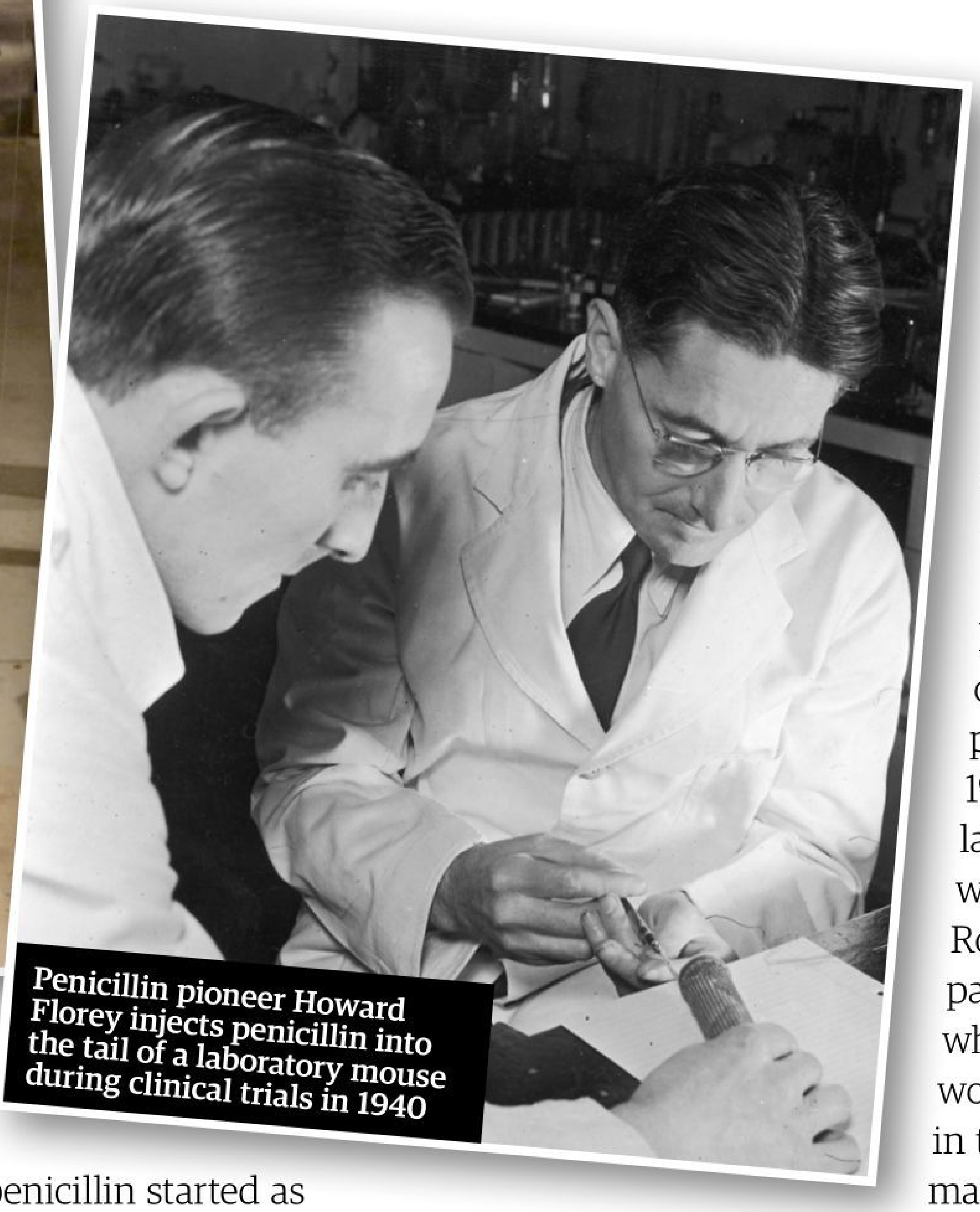
In the spring of 1929, Fleming published his findings regarding penicillin in the *British Journal Of Experimental Pathology*; however, the scientific community showed little interest. This may have been due in part to his concentration on its use in topical wound application rather than its therapeutic potential. Combined with persistent challenges in isolation, stabilisation, and production in quantity, his further research efforts were frustrating despite periodic successes. During the 1930s his attempts to interest other scientists, particularly those with backgrounds in chemistry who might address these tactical obstacles, were largely discounted. Other scientists did request samples, notably Professor Harold Raistrick of the London School of Hygiene and Tropical Medicine, but he failed to develop penicillin in a more pure and effective form.

By 1940, Fleming was 59 and contemplating retirement. On the eve of World War II, however, two researchers at the Sir William Dunn School of Pathology at Oxford University – Howard Florey and Ernst Chain – had worked on isolating and purifying penicillin. Their effort involved culturing penicillin in a variety of containers, from bathtubs to bowls. Biochemist Norman Heatley was then able to extract penicillin in volume as filtrate became available through a new process, as was biochemist Edward Abraham. The team employed a group of 'penicillin girls,' paying them £2 per week to oversee the fermentation process.

When the Oxford team published its first reports, Fleming telephoned Florey that he wanted to visit. When Florey informed Chain, the latter responded, "Good God! I thought he was dead."

Fleming, however, later put his interest into perspective. "In my first publication I might have claimed that I had come to the conclusion, as a result of serious study of the literature and deep thought, that valuable antibacterial substances were made by moulds and that I set out to investigate the problem.

> Fleming, Florey and Chain were awarded the Nobel Prize for medicine in 1945 for the creation of the 'wonder drug'



Penicillin pioneer Howard Florey injects penicillin into the tail of a laboratory mouse during clinical trials in 1940

That would have been untrue and I preferred to tell the truth that penicillin started as a chance observation. My only merit is that I did not neglect the observation and that I pursued the subject as a bacteriologist. My publication in 1929 was the starting-point of the work of others who developed penicillin."

Florey became the catalyst for the research into unlocking the practical application of penicillin. Chain was a brilliant chemist, a Jewish émigré who had fled Nazi Germany in 1933 and accepted a post at Oxford. Although Florey and Chain were often at odds, they managed to work together, focusing their research on a group of 50 mice, half injected with streptococcus bacteria and left untreated, while the other half was treated with penicillin and survived the onslaught of the deadly pathogen. The issues of extraction and production in quantity remained until a chance discovery in the summer of 1941. Mary Hunt, a laboratory assistant, brought in a cantaloupe that was overgrown with a golden-tinted mould. Analysis revealed it was of the Penicillium family, actually chrysogenum, capable of yielding 200 times the amount of Fleming's original Penicillium notatum. Further experimentation and processing yielded more than 1,000 times the usable penicillin as the earliest notatum lots.

The accidental discovery of penicillin lead to the era of antibiotics after 1945

Meanwhile, as British pharmaceutical companies had become engaged, Florey and Heatley travelled to the United States to enlist the support of drug manufacturers. Production of penicillin increased exponentially during World War II. Its curative power was proven beyond doubt as deaths from infection plummeted in comparison to the horrifying statistics of the Great War, when the mortality rate among soldiers from bacterial pneumonia was 18 per cent. Thanks to penicillin it fell below one per cent during World War II.

Countless lives were saved, and during the first half of 1942, a total of 400 million units of penicillin were produced. American manufacturers alone generated 650 billion units per month by the end of the war in 1945.

Understandably, Fleming had largely bowed out of the development of penicillin during the 1930s. He continued with laboratory research and was elected a Fellow of the Royal Society in 1943. Sareen passed away in 1949, after which he found solace in his work, spending long hours in the laboratory. In 1953, he married Dr Amalia Koutsouri-Vourekas, who was a fellow researcher at St Mary's.

Quiet, reserved, and modest, Fleming generally eschewed the limelight. However, he experienced a surge in popularity with the elevation of penicillin to the status of a wonder drug. His discovery of the antibiotic was hailed in the media, sometimes at the expense of the Oxford team that had made the widespread use of penicillin possible. In 1945, Fleming, Florey, and Chain were jointly awarded the Nobel Prize in Physiology or Medicine. Fleming remained a visionary, and in his acceptance speech he warned of the possible misuse of penicillin producing antibiotic-resistant bacteria, a phenomenon that has been realised today.

"It is not difficult to make microbes resistant to penicillin by exposing them to concentrations not sufficient to kill them," he commented, "and the same thing has occasionally happened in the body. The time may come when penicillin can be bought by anyone in the shops. Then there is the danger that the ignorant man may easily underdose himself and by exposing his microbes to non-lethal quantities of the drug make them resistant."

During his later years, Fleming was showered with honours. He was knighted by King George VI as a Knight Bachelor in 1944, received the Albert Gold Medal from the Royal Society of Arts in 1946 and the Medal for Merit, at the time the highest civilian award presented by the US government, in 1947. In 1948, the government of Spain recognised him with the Knight Grand Cross of the Order of Alfonso X the Wise, and he retired from St Mary's. He served as a Member of the Pontifical Academy of Science and as president of the Society for General Microbiology and was rector of Edinburgh University from 1951-1954, while receiving honorary degrees from nearly 30 American and European universities. His son, Robert, had become a practicing physician.

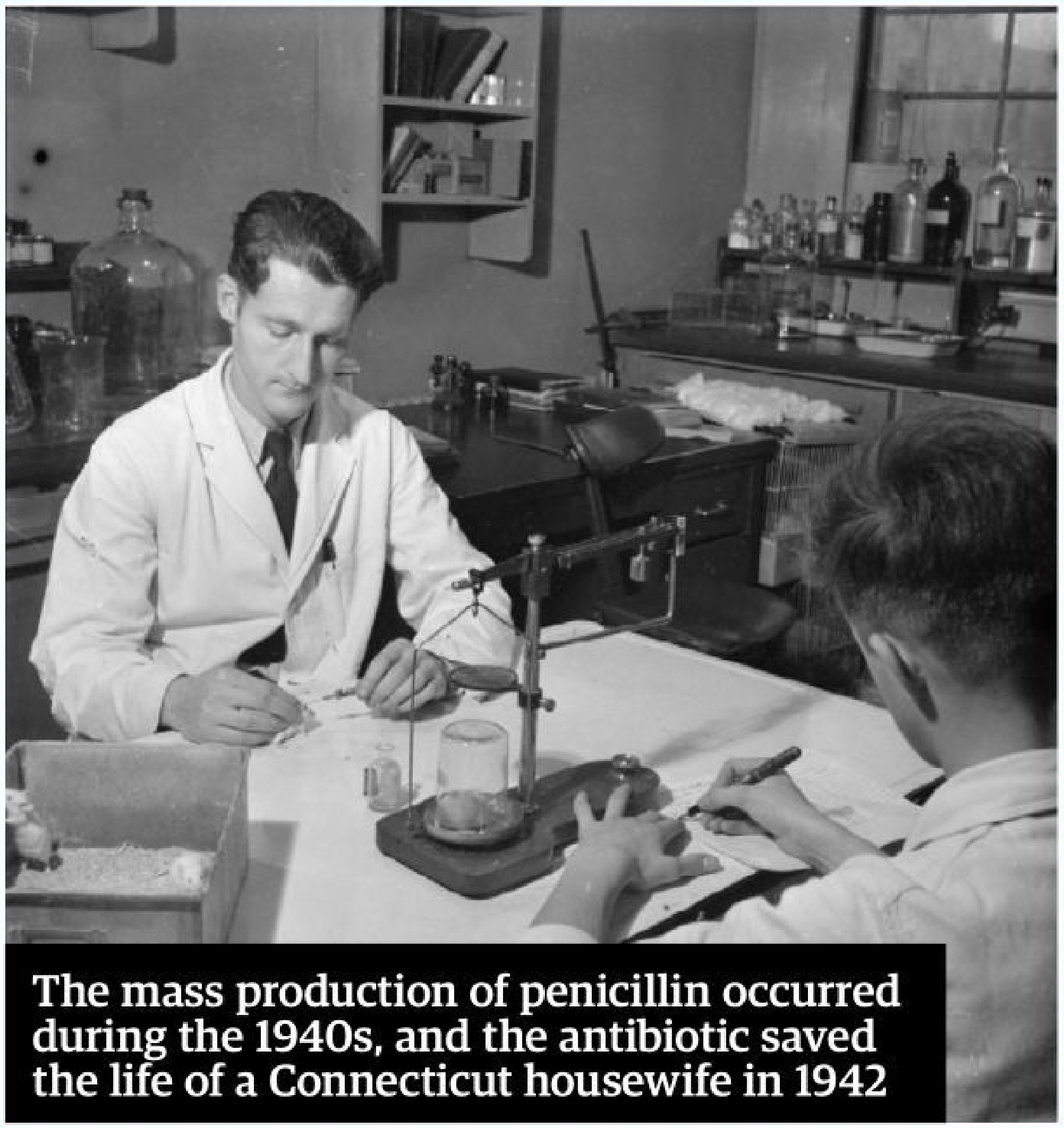
Fleming died suddenly at his home in Chelsea of a heart attack on 11 March 1955, after experiencing discomfort that he attributed to gastric distress. After his wife phoned the doctor due to the onset of nausea, Fleming told them both that a house call would not be necessary. Minutes later, he was gone. He was interred at St Paul's Cathedral in London.

Fleming is remembered as a titan in the field of microbiology as noted in *TIME* magazine, which listed him in 1999 as one of the 100 Most Important People of the 20th Century. In 2002, a BBC poll listed him among the 100 Greatest Britons, and in 2009 he was third among the Greatest Scots in an STV network opinion poll, trailing only William Wallace and Robert Burns.

CONDUCTING CLINICAL TRIALS

In 1941, Howard Florey led the first clinical trials of therapeutic penicillin. In the autumn of 1940, Albert Alexander, a 48-year-old reserve constable with County of Oxford Police had cut his face while working in his rose garden. The slight injury was enough to introduce both streptococcus and staphylococcus bacteria, and a raging infection developed. He was admitted to the Radcliffe Infirmary and treated with sulfa drugs, which were ineffective. Alexander's condition steadily worsened, and infection spread to his eyes, lungs and shoulder.

When Alexander's case was brought to Florey's attention, trials had been conducted only on animals. The reaction of a human to large doses of antibiotic was unknown. Alexander appeared terminal; therefore, the introduction of penicillin was approved. On 12 February 1941, the patient was injected and within a day he exhibited general improvement. However, penicillin was not yet available in sufficient quantity to maintain the necessary dosages. Available supplies were exhausted within five days. Alexander relapsed and died on 15 March. A year later, sufficient penicillin was available to treat the first patient successfully. Housewife Anne Miller of New Haven, Connecticut, had contracted a streptococcus infection following a miscarriage. Near death, she was saved by penicillin. Her hospital chart resides in the Smithsonian Institution.



The mass production of penicillin occurred during the 1940s, and the antibiotic saved the life of a Connecticut housewife in 1942

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KEY DISCOVERIES

Discover everything you need to know about the greatest inventions, live-saving remedies and impressive medical firsts throughout history

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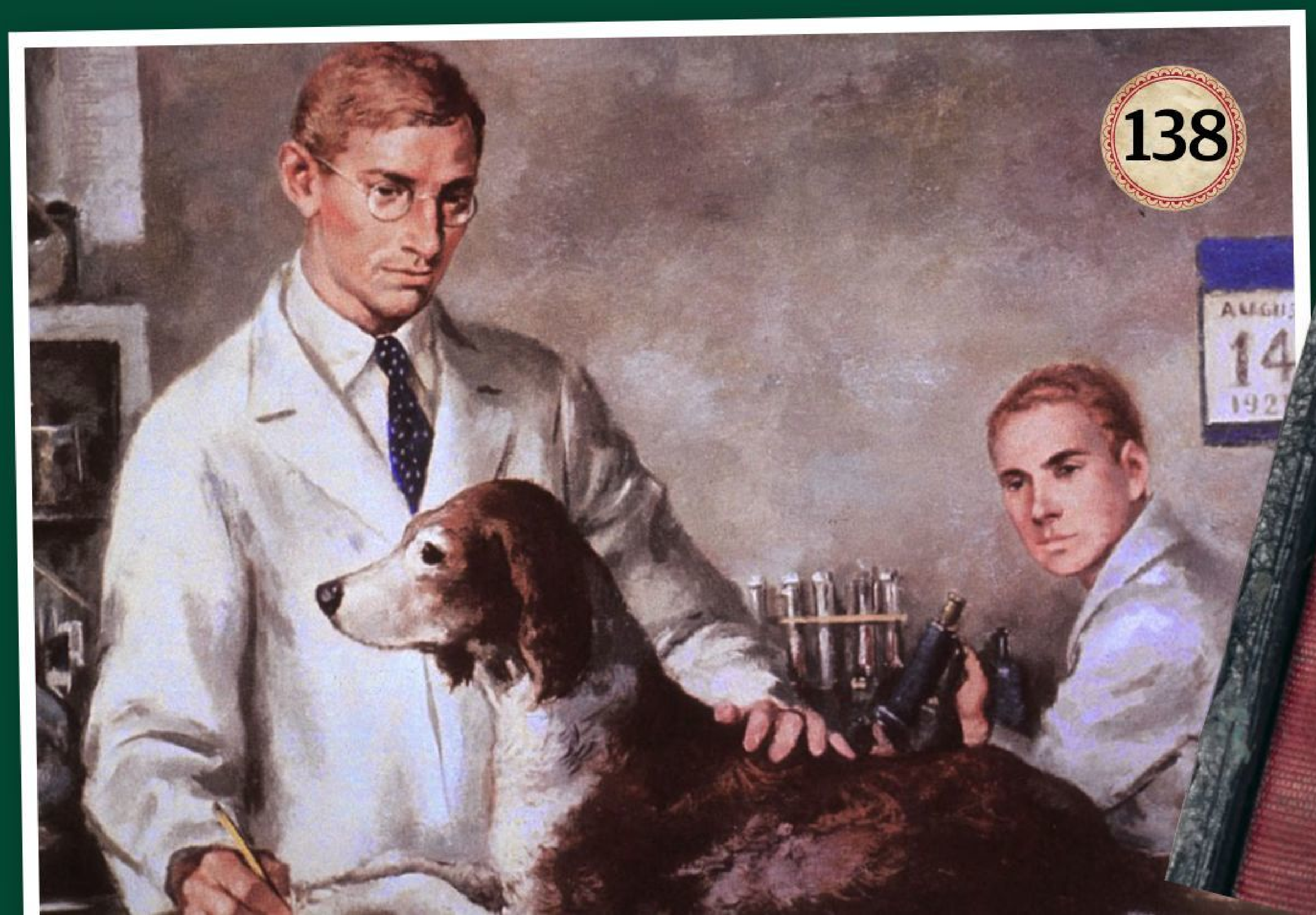
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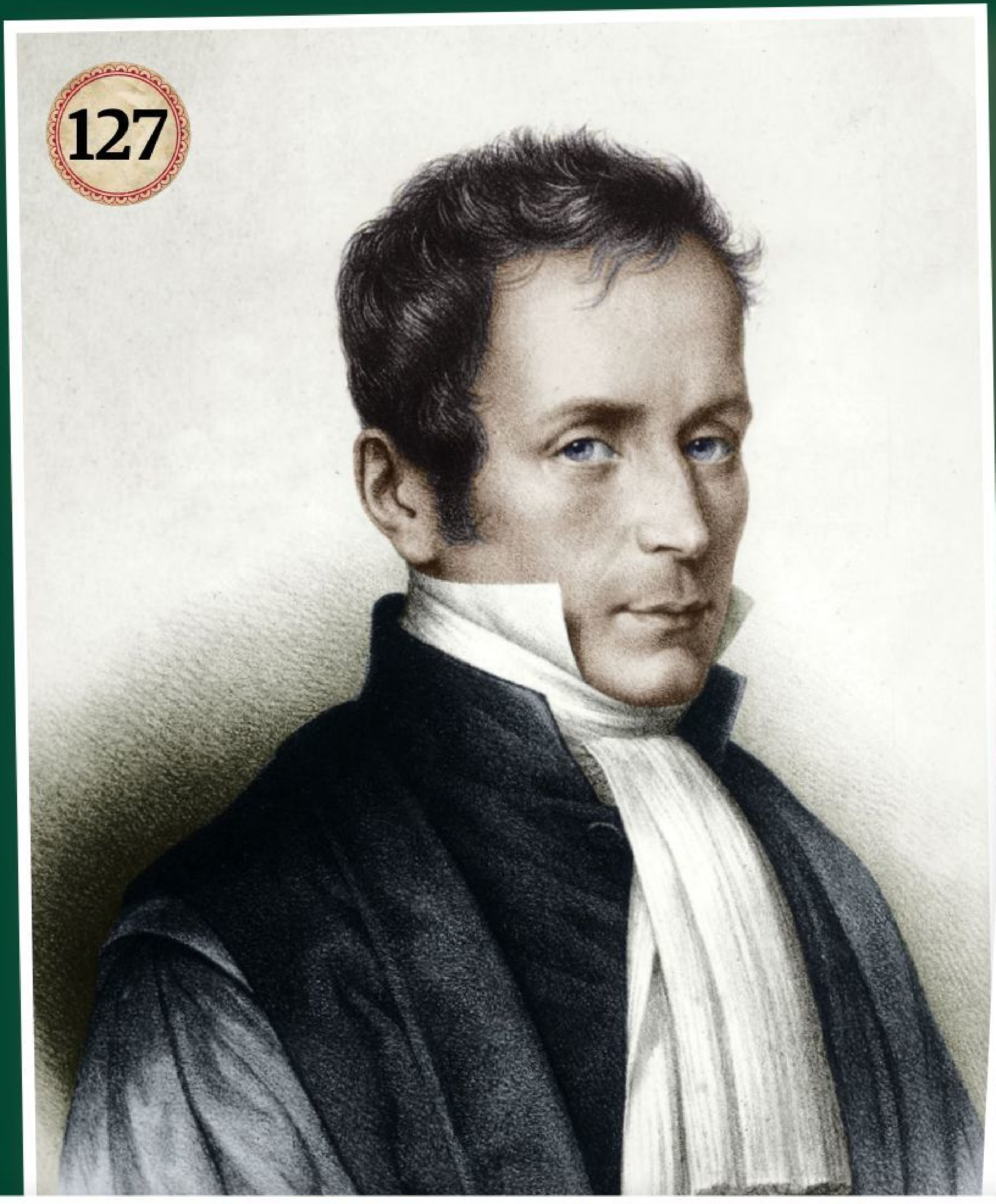

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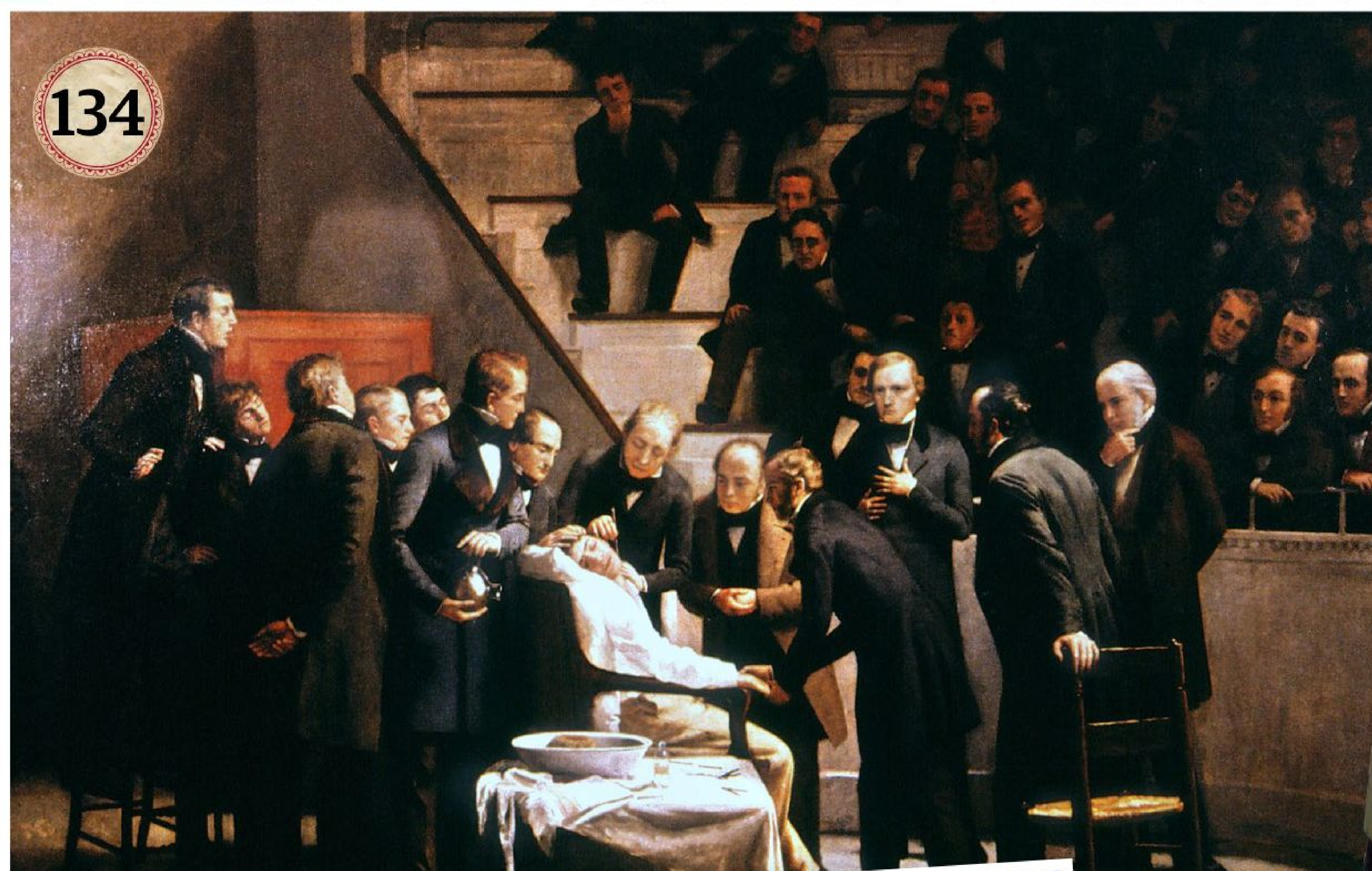

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MEDICAL DEVICES

THROUGH HISTORY

These torturous-looking instruments and machines were actually designed to save lives!

Neolithic trepans were made from flint or shark's teeth

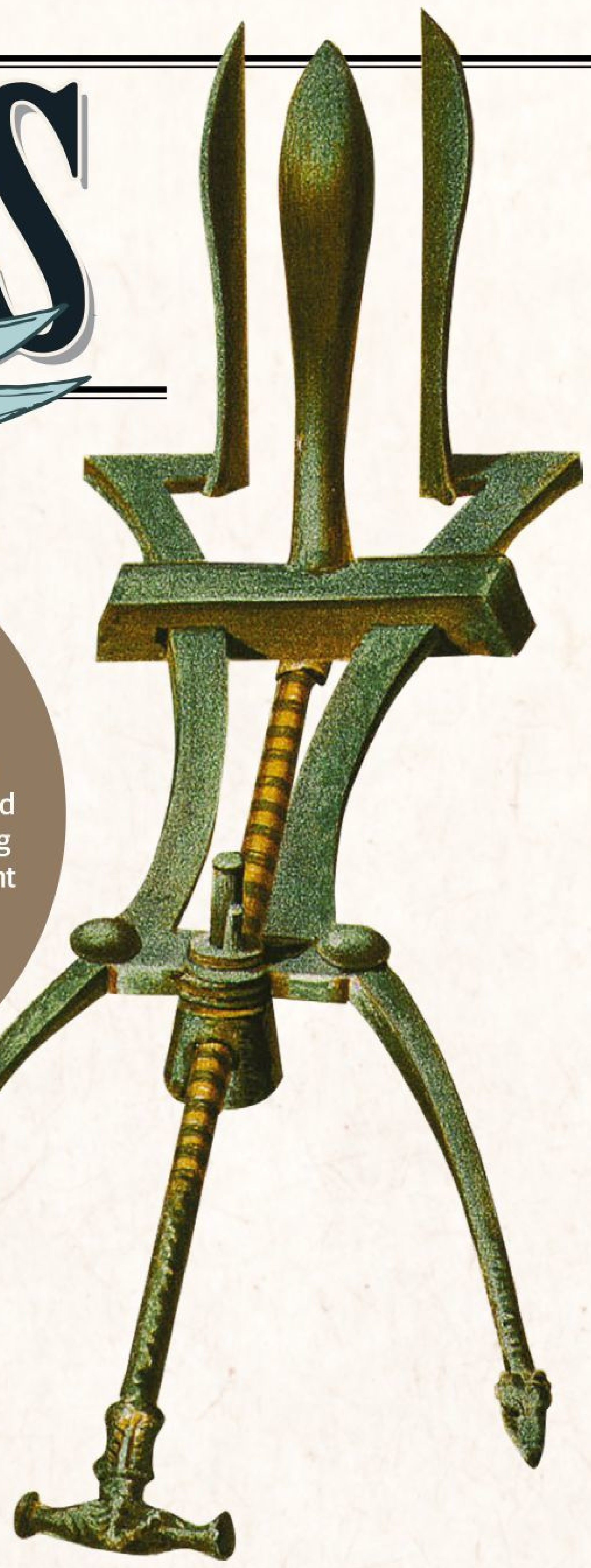
TREPAN 6500 BCE, EUROPE

These days, if we have a headache we can take an aspirin, have a glass of water, and it usually disappears within an hour or two. But in Neolithic times, the cure was a lot more gruesome. A hole was cut in the skull of the patient to expose the dura mater – the brain's tough outer layer. This was done using a trepan, which in Neolithic times was simply a piece of flint attached to a wooden shaft. In some parts of the globe, trepanning is still used today to treat mental disorders.

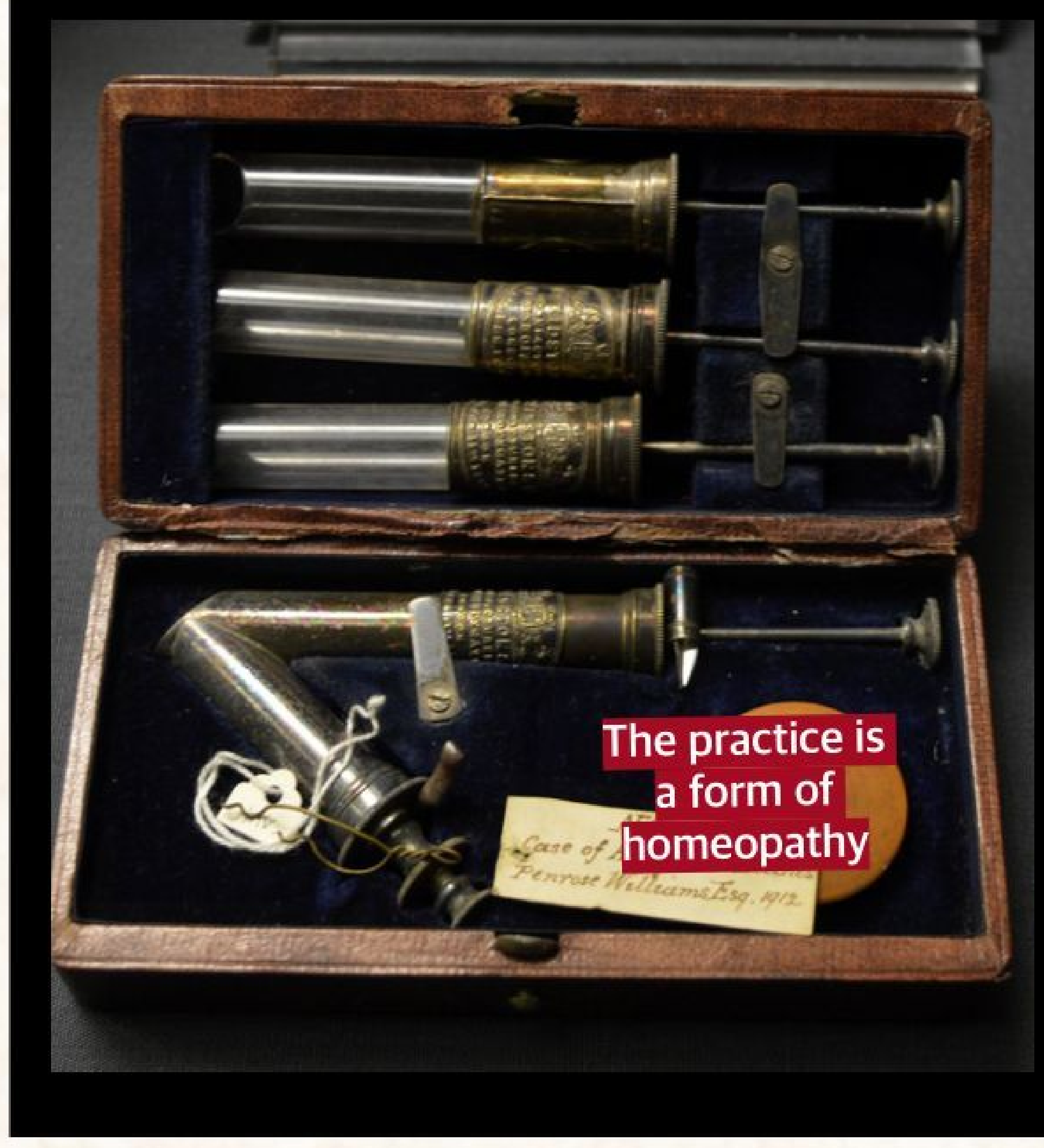
Abu al-Qasim Al-Zahrawi

936-1013, ARAB

Al-Zahrawi devoted his life to the advancement of medicine. He was an advocate of cauterisation and introduced over 200 surgical instruments, including forceps – drastically decreasing the infant mortality rate. He was also the first physician to describe an ectopic pregnancy and the first to identify the hereditary nature of haemophilia.



Speculums barely diverged from this Roman design until the 20th century



The practice is a form of homeopathy

ARTIFICIAL LEECH 1840, GERMANY

Bloodletting was a very common practice for many medical conditions throughout different periods of history. In 1840, Carl Baunscheidt, a German inventor and mechanic, created a device that served the same purpose as the wriggly bloodsucking creatures. The multiple blades would cut into the patient's skin, creating a wound and then the cylinder would be produce a vacuum that would suck up the patient's blood. At the time of it's creation, it was alleged that baldness, toothaches, whooping cough and some mental disorders could be cured with it.

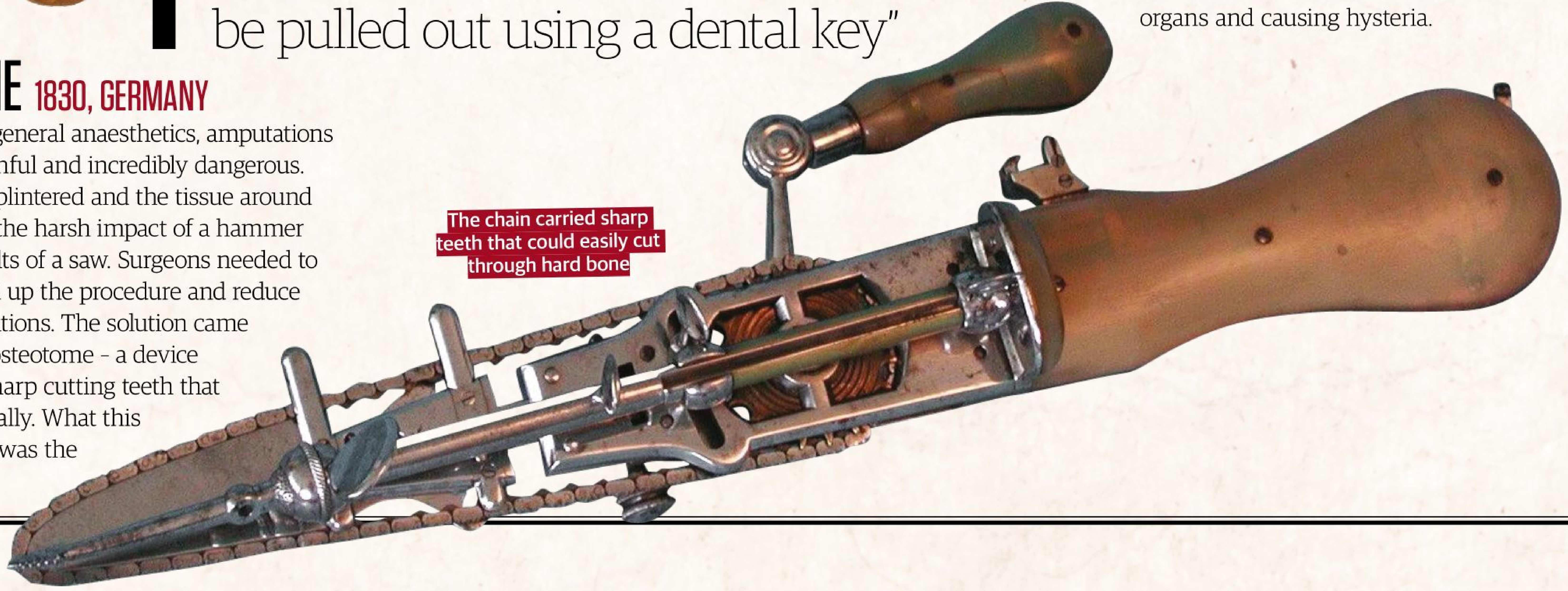
SPECULUM 79 CE, ITALY

Though the eruption of Mount Vesuvius destroyed the lives of thousands of Roman people, the artefacts recovered from the ash-covered city of Pompeii provide a never-before-seen insight into the lives they led. This includes medicine. Several surgical instruments have been found here, including this terrifying looking speculum. Roman gynaecology was relatively primitive, and physicians even believed that a woman's womb could 'wander' around the body, wreaking havoc on her internal organs and causing hysteria.

> "Rather than treat a toothache with antibiotics, infected teeth would have to be pulled out using a dental key"

OSTEOTOME 1830, GERMANY

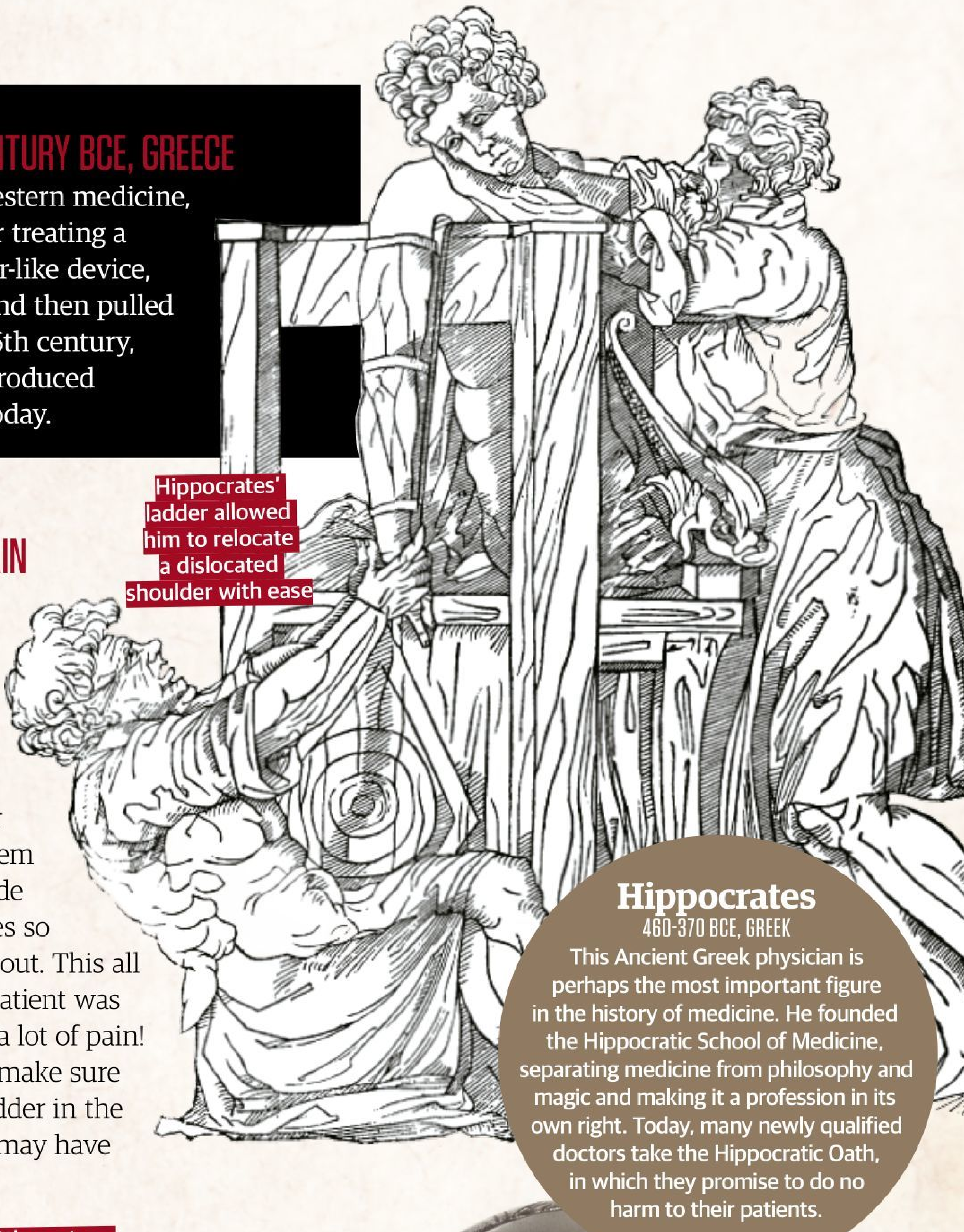
In the days before general anaesthetics, amputations were incredibly painful and incredibly dangerous. Bones were often splintered and the tissue around them damaged by the harsh impact of a hammer and chisel or the jolts of a saw. Surgeons needed to find a way to speed up the procedure and reduce the risk of complications. The solution came in the form of the osteotome – a device with a chain and sharp cutting teeth that was cranked manually. What this device was, in fact, was the first-ever chainsaw.



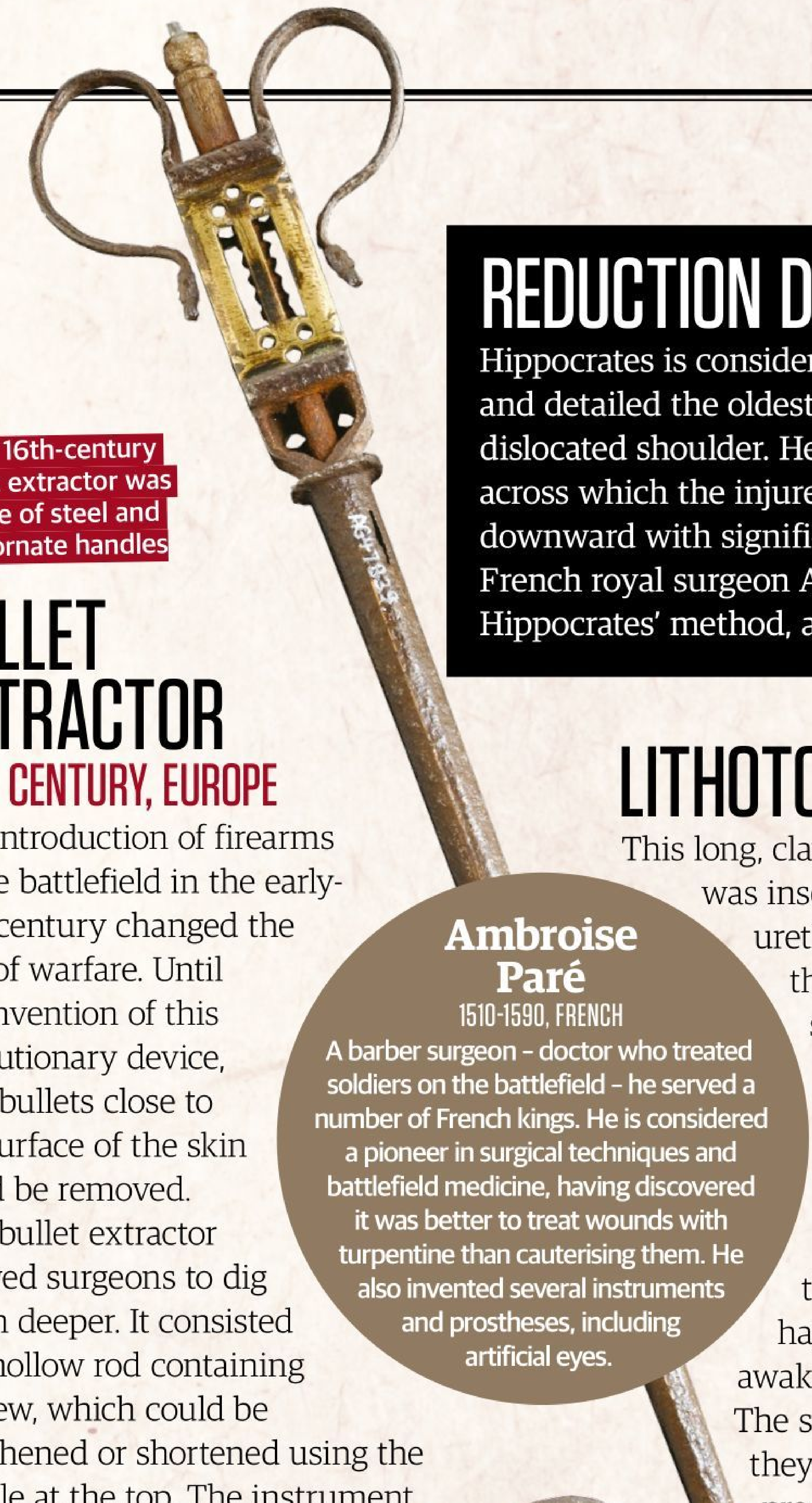
The chain carried sharp teeth that could easily cut through hard bone

REDUCTION DEVICE 5TH CENTURY BCE, GREECE

Hippocrates is considered the father of Western medicine, and detailed the oldest known method for treating a dislocated shoulder. He developed a ladder-like device, across which the injured arm was slung and then pulled downward with significant force. In the 16th century, French royal surgeon Ambroise Paré reintroduced Hippocrates' method, and it is still used today.



Hippocrates' ladder allowed him to relocate a dislocated shoulder with ease



This 16th-century bullet extractor was made of steel and had ornate handles

BULLET EXTRACTOR

16TH CENTURY, EUROPE

The introduction of firearms to the battlefield in the early-13th century changed the face of warfare. Until the invention of this revolutionary device, only bullets close to the surface of the skin could be removed. This bullet extractor allowed surgeons to dig much deeper. It consisted of a hollow rod containing a screw, which could be lengthened or shortened using the handle at the top. The instrument was placed in the wound and the screw lengthened in order to pierce the bullet and remove it.

Ambroise Paré

1510-1590, FRENCH

A barber surgeon – doctor who treated soldiers on the battlefield – he served a number of French kings. He is considered a pioneer in surgical techniques and battlefield medicine, having discovered it was better to treat wounds with turpentine than cauterising them. He also invented several instruments and prostheses, including artificial eyes.

LITHOTOME 1780, BRITAIN

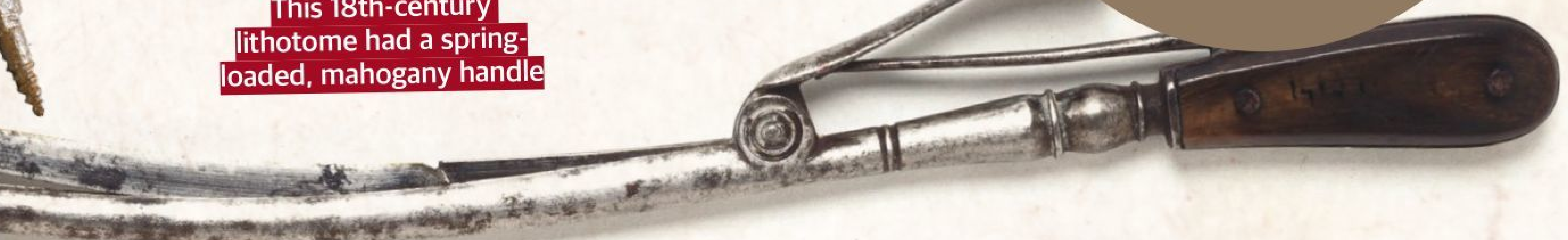
This long, claw-like instrument was inserted up the urethra and into the bladder. The surgeon would then use it to grip onto small bladder stones and pull them out, or use the blade to cut up larger ones so they could be weed out. This all happened while the patient was awake – undoubtedly in a lot of pain! The surgeon also had to make sure they didn't slice the bladder in the process, or the patient may have bled to death.

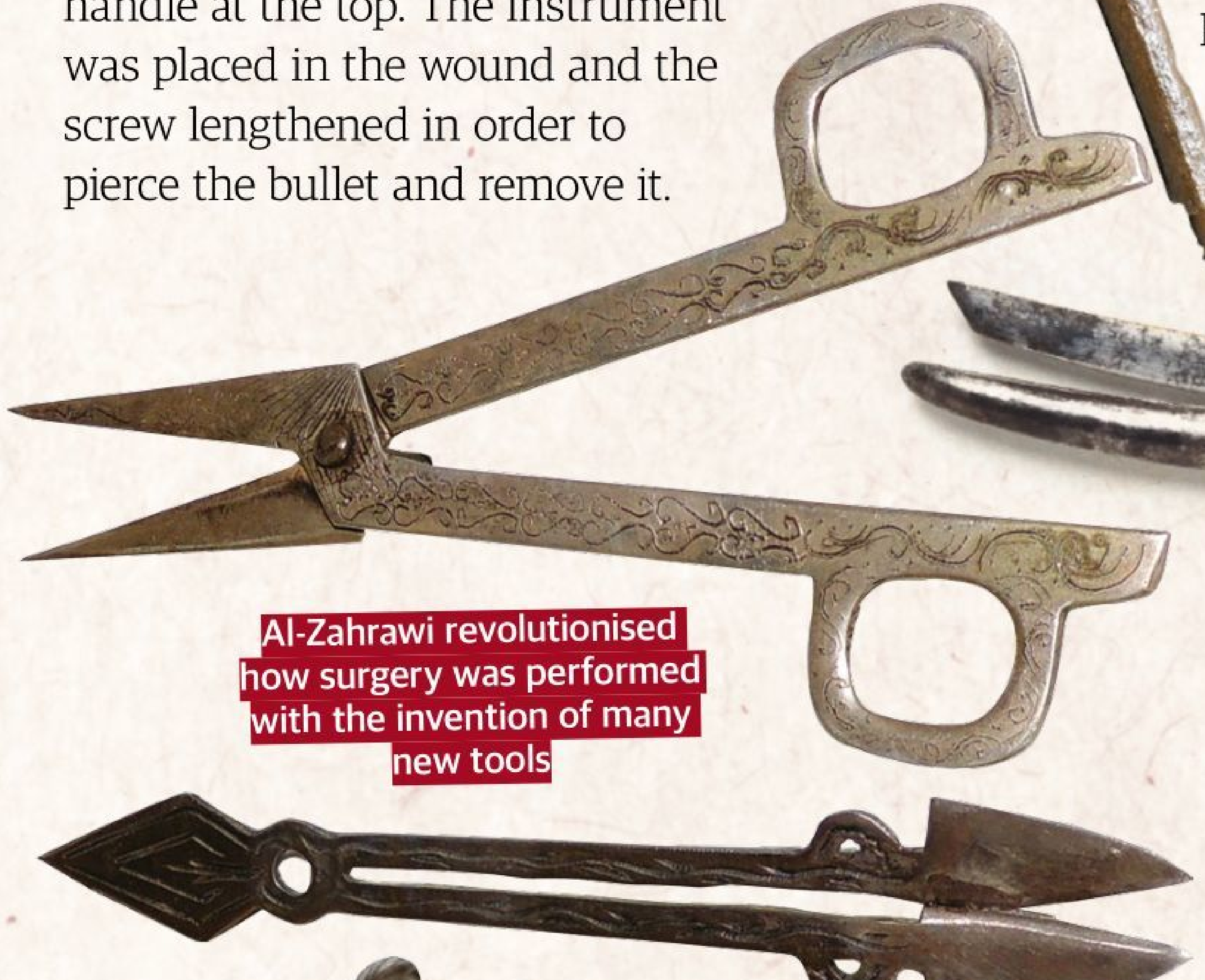
Hippocrates

460-370 BCE, GREEK

This Ancient Greek physician is perhaps the most important figure in the history of medicine. He founded the Hippocratic School of Medicine, separating medicine from philosophy and magic and making it a profession in its own right. Today, many newly qualified doctors take the Hippocratic Oath, in which they promise to do no harm to their patients.

This 18th-century lithotome had a spring-loaded, mahogany handle



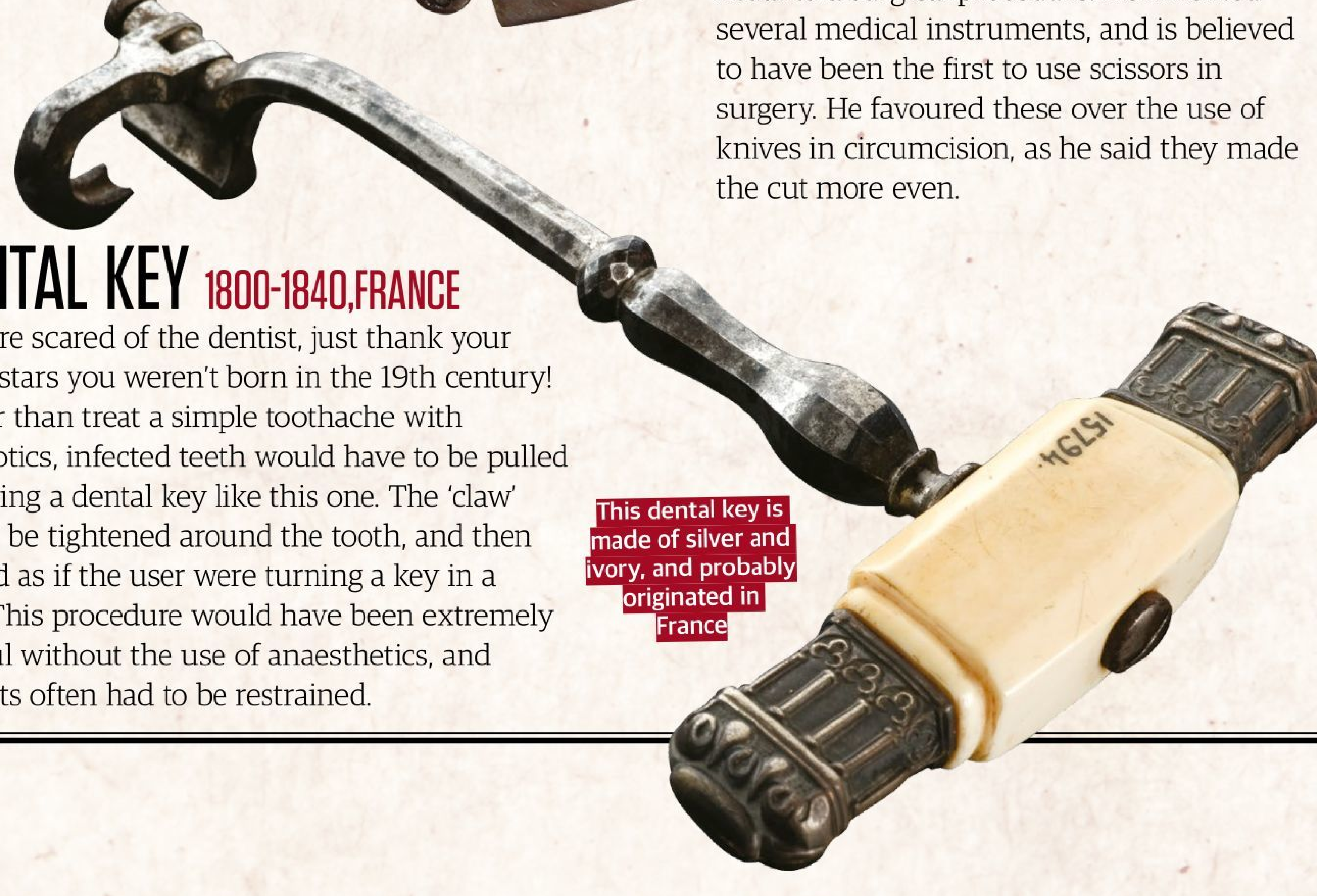


Al-Zahrawi revolutionised how surgery was performed with the invention of many new tools

CIRCUMCISION SCISSORS

10TH/11TH CENTURY, MUSLIM SPAIN

Medieval surgeon Abu al-Qasim al-Zahrawi transformed circumcision from a religious ritual to a surgical procedure. He invented several medical instruments, and is believed to have been the first to use scissors in surgery. He favoured these over the use of knives in circumcision, as he said they made the cut more even.



This dental key is made of silver and ivory, and probably originated in France

DENTAL KEY 1800-1840,FRANCE

If you're scared of the dentist, just thank your lucky stars you weren't born in the 19th century! Rather than treat a simple toothache with antibiotics, infected teeth would have to be pulled out using a dental key like this one. The 'claw' would be tightened around the tooth, and then rotated as if the user were turning a key in a lock. This procedure would have been extremely painful without the use of anaesthetics, and patients often had to be restrained.

Newer CT scanners can produces 3D images of our insides

CT SCANNER PRESENT, BRITAIN

The pinnacle of modern medicine, the CT scanner allows doctors to see detailed images of our insides. It was originally designed to take pictures of the brain, and the first time it was used in 1971 it revealed a brain tumour in a 41-year-old patient. Now doctors can use them to detect all kinds of abnormalities in any part of the body. It works by beaming X-rays through a person, which are then received by the machine and the information sent to a computer. This then processes the information to create an image.

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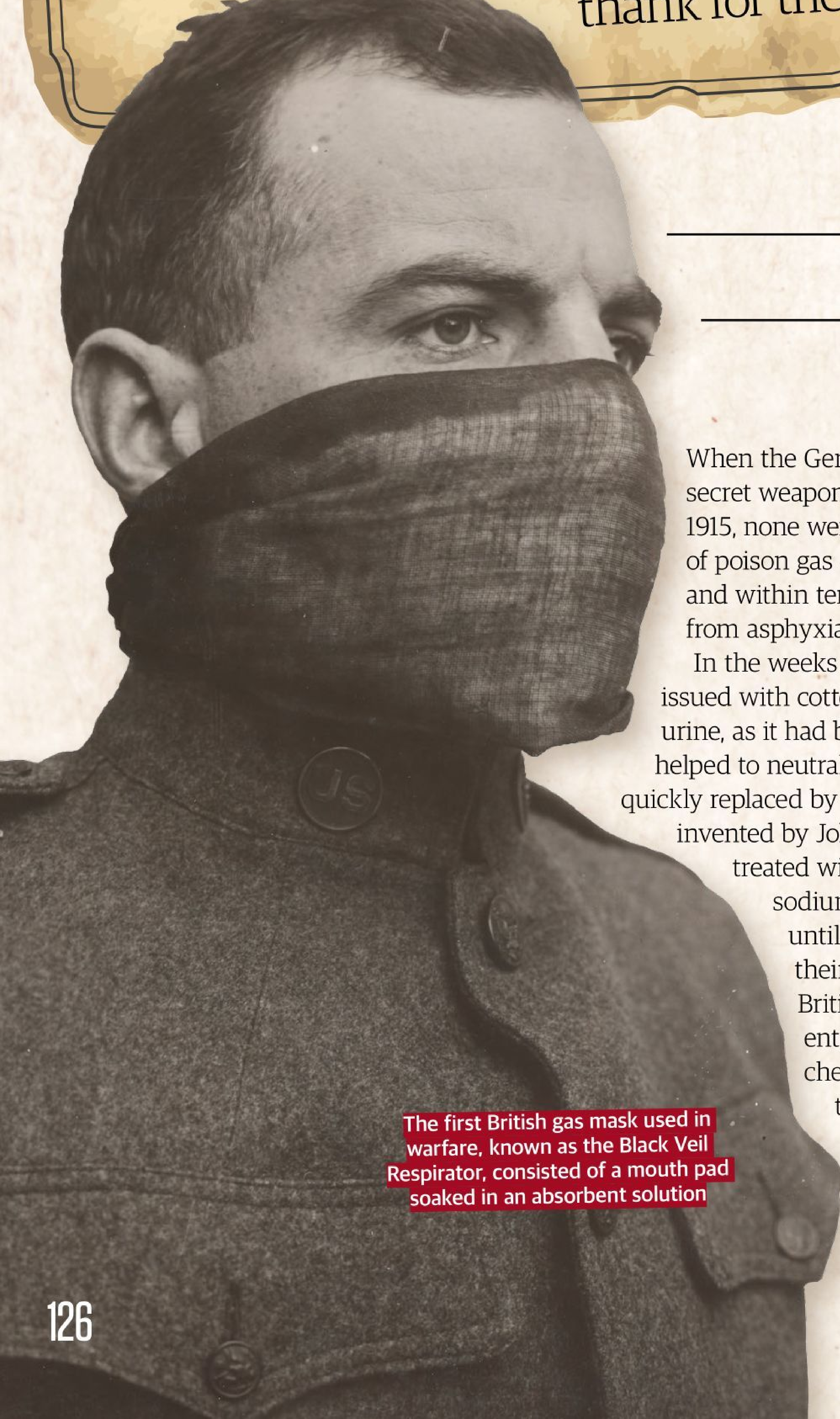
THE STORIES BEHIND HISTORY'S GREATEST MEDICAL INVENTIONS

Whether their technologies were stumbled across by accident or the result of years – perhaps millennia – of development, we have many people to thank for these life-saving devices

Preventing the spread of disease, improving diagnosis and saving lives are just three of the many ways in which medical inventions have changed our world. With so much cutting-edge technology dominating the headlines, from stem cells to genome editing, it's often easy to forget the impact that simple inventions like the wheelchair and the thermometer have had on our lives. We can't always put our finger on the person responsible for each of them either – often they are the result of many minds working together, standing on the shoulders of their forefathers. Where patent records and other important documents have been lost to the abyss of time, so too has our memory of those great inventors of yore. But with a little bit of digging, and a whole lot of scepticism, we can attempt to piece their histories together.



The first British gas mask used in warfare, known as the Black Veil Respirator, consisted of a mouth pad soaked in an absorbent solution

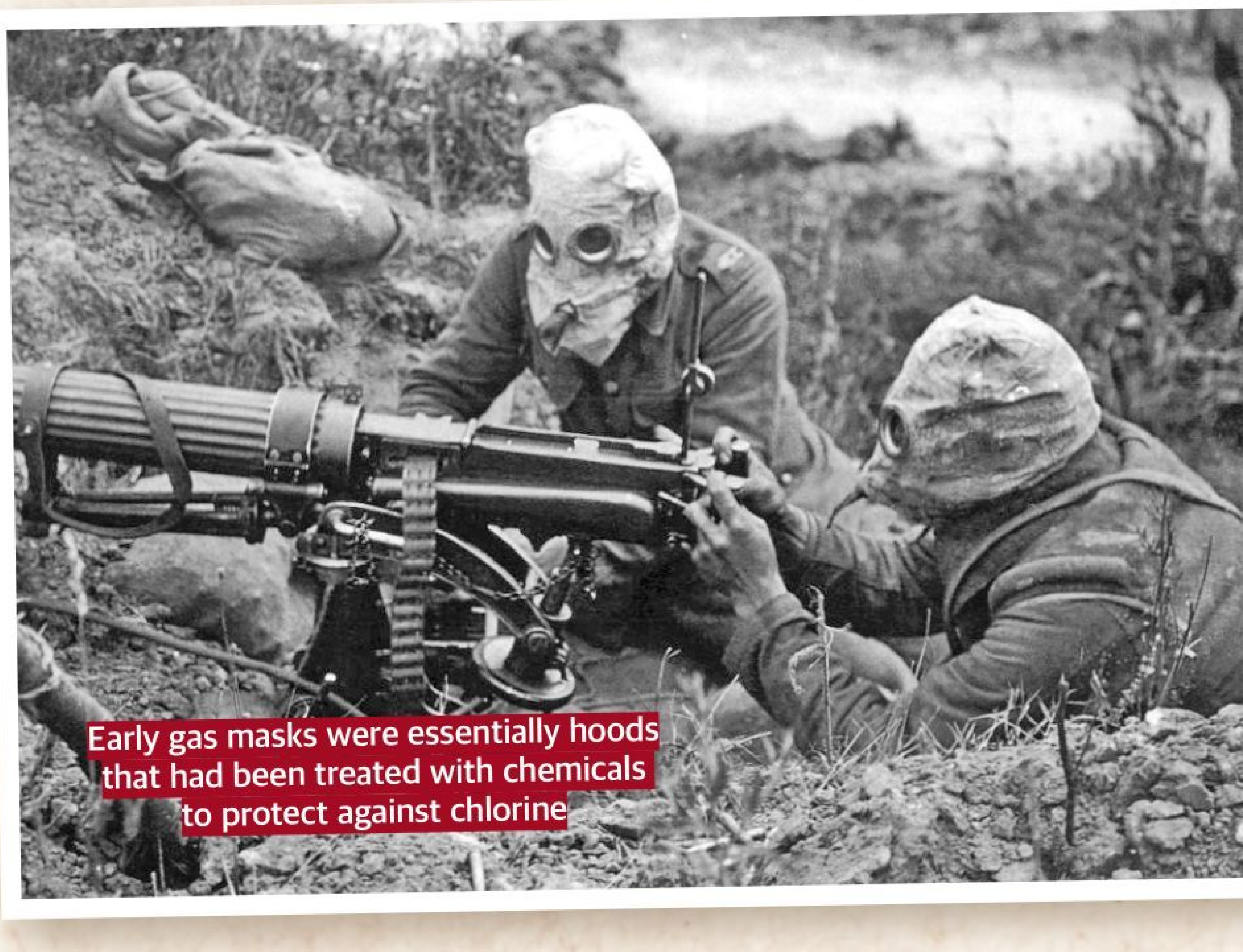
GAS MASK

John Scott Haldane Scotland, 1915

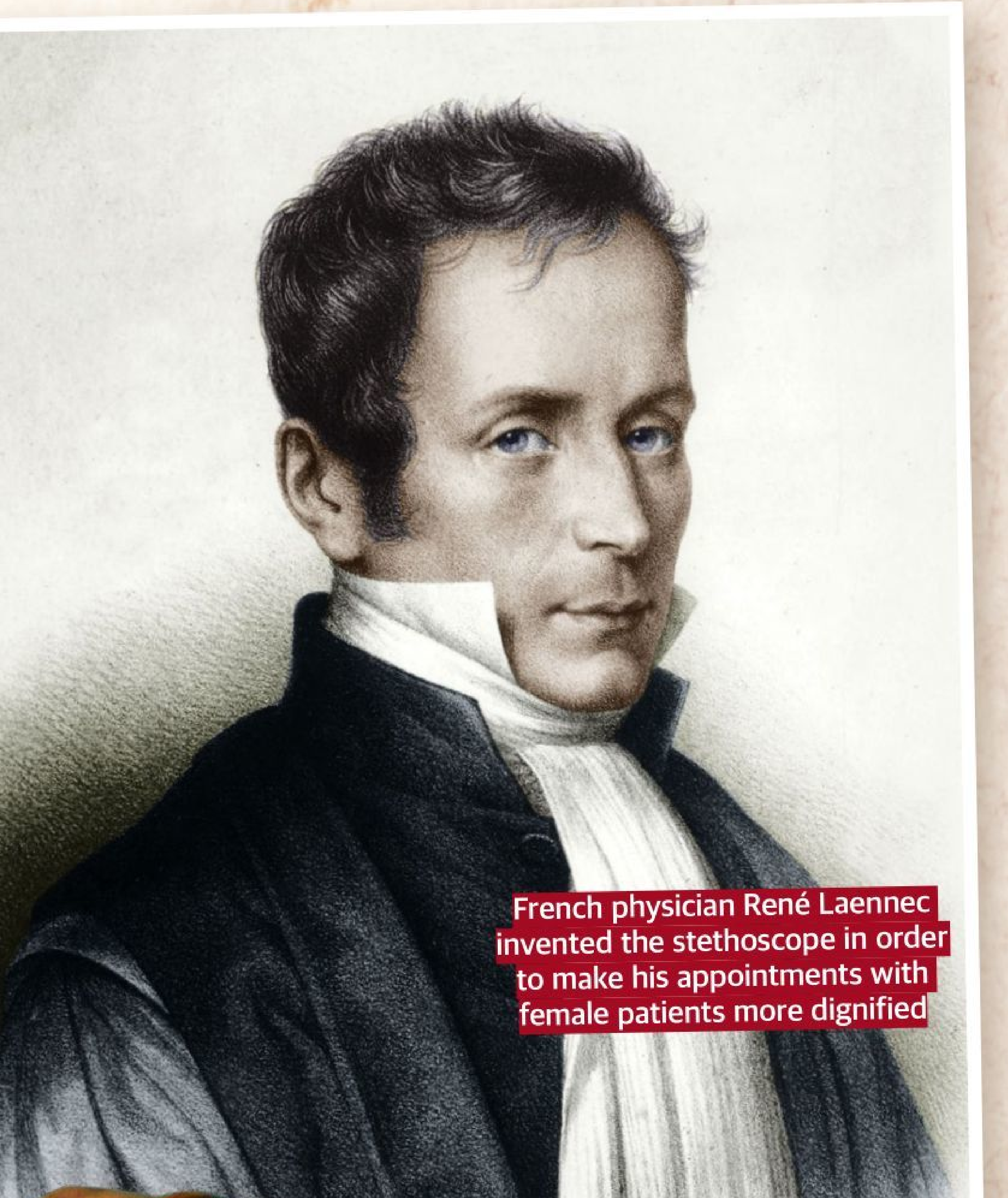
With the emergence of chemical warfare on the battlefields of World War I, a protective mask had to be invented – and fast

When the German army unleashed their secret weapon upon Allied soldiers in April 1915, none were prepared. A thick, yellow cloud of poison gas advanced across No Man's Land and within ten minutes, thousands had died from asphyxia or been permanently blinded.

In the weeks that followed, soldiers were issued with cotton mouth pads soaked in urine, as it had been discovered that ammonia helped to neutralise chlorine. These were quickly replaced by the Black Veil Respirator, invented by John Scott Haldane, which was treated with a far less stomach-churning, sodium-based solution. It wasn't until July that troops would receive their first full-face gas masks. The British Smoke Hood fitted over the entire head and was made of a chemical-absorbing fabric, while a thermoplastic window provided visibility. It had been invented by Dr Cluny Macpherson, a Newfoundland physician who had been enlisted into the Allied forces. However, it wasn't in use for long as by summer of the following year, the Small Box Respirator had been introduced, which consisted of a face mask with glass eye-pieces, connected via a rubber hose to a metal 'small box' filter containing chemical absorbents. This remained the most effective and practical gas mask until well beyond the end of the war.



Early gas masks were essentially hoods that had been treated with chemicals to protect against chlorine



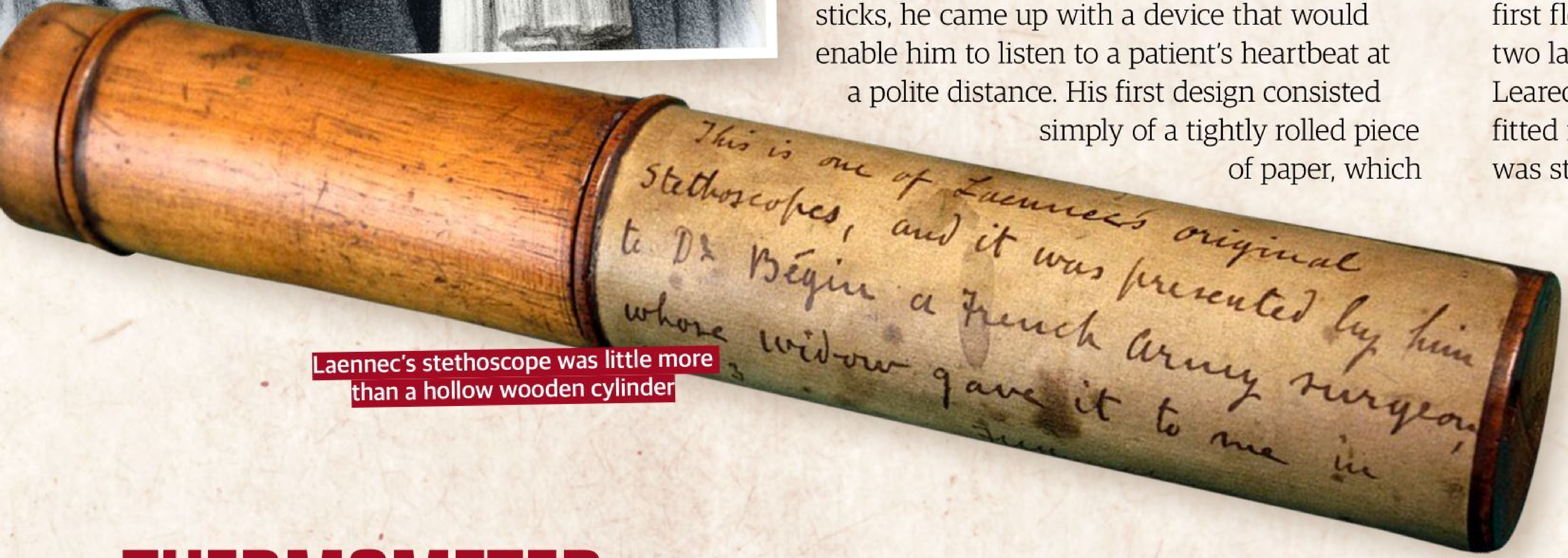
French physician René Laennec invented the stethoscope in order to make his appointments with female patients more dignified

STETHOSCOPE

René Laennec France, 1816

It was only out of embarrassment that this now-invaluable medical device was invented

Imagine going to the doctor and being asked if he or she could listen to your heart, only for them to proceed to place their ear against your chest. Awkward, right? In the days before stethoscopes, this was how it was done. Physician René Laennec found it incredibly undignified, especially when a lady was involved, so resigned himself to inventing a solution. Upon watching children sending signals using long, hollow sticks, he came up with a device that would enable him to listen to a patient's heartbeat at a polite distance. His first design consisted simply of a tightly rolled piece of paper, which when placed between the chest and his ear, could amplify the sound of the heart. He then translated his design into a hollow wooden cylinder, eventually adding a funnel at one end that augmented the sound. He named his new instrument the 'stethoscope', from the Greek words stethos, meaning chest, and skopos, meaning examination. The stethoscope quickly gained popularity and spread across Europe. The first flexible versions were invented a decade or two later, while in 1851, Irish physician Arthur Leared invented the binaural stethoscope, which fitted into both ears. Finally, in 1852, the design was standardised by George Philip Cammann.


This is one of Laennec's original
Stethoscopes, and it was presented by him
to Dr Bégin a French Army surgeon
whose widow gave it to me in

Laennec's stethoscope was little more than a hollow wooden cylinder

> "The stethoscope quickly gained in popularity and spread across Europe"

THERMOMETER

Daniel Gabriel Fahrenheit Netherlands, 1714

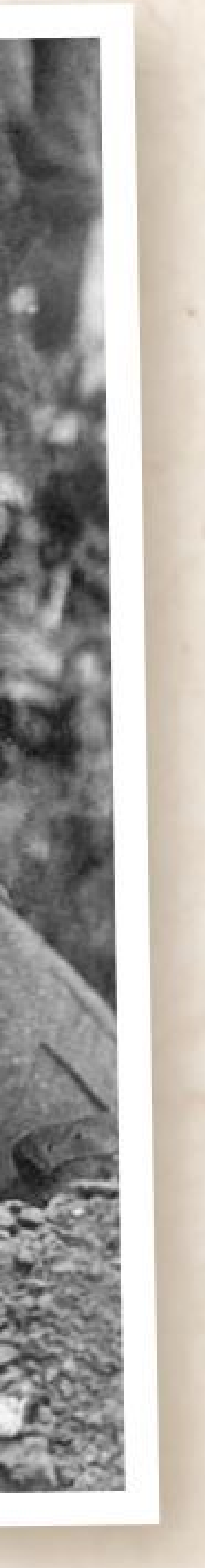
Humans have been aware of the underlying principles of the thermometer for millennia, but it wasn't until the 18th century that a standardised design was created

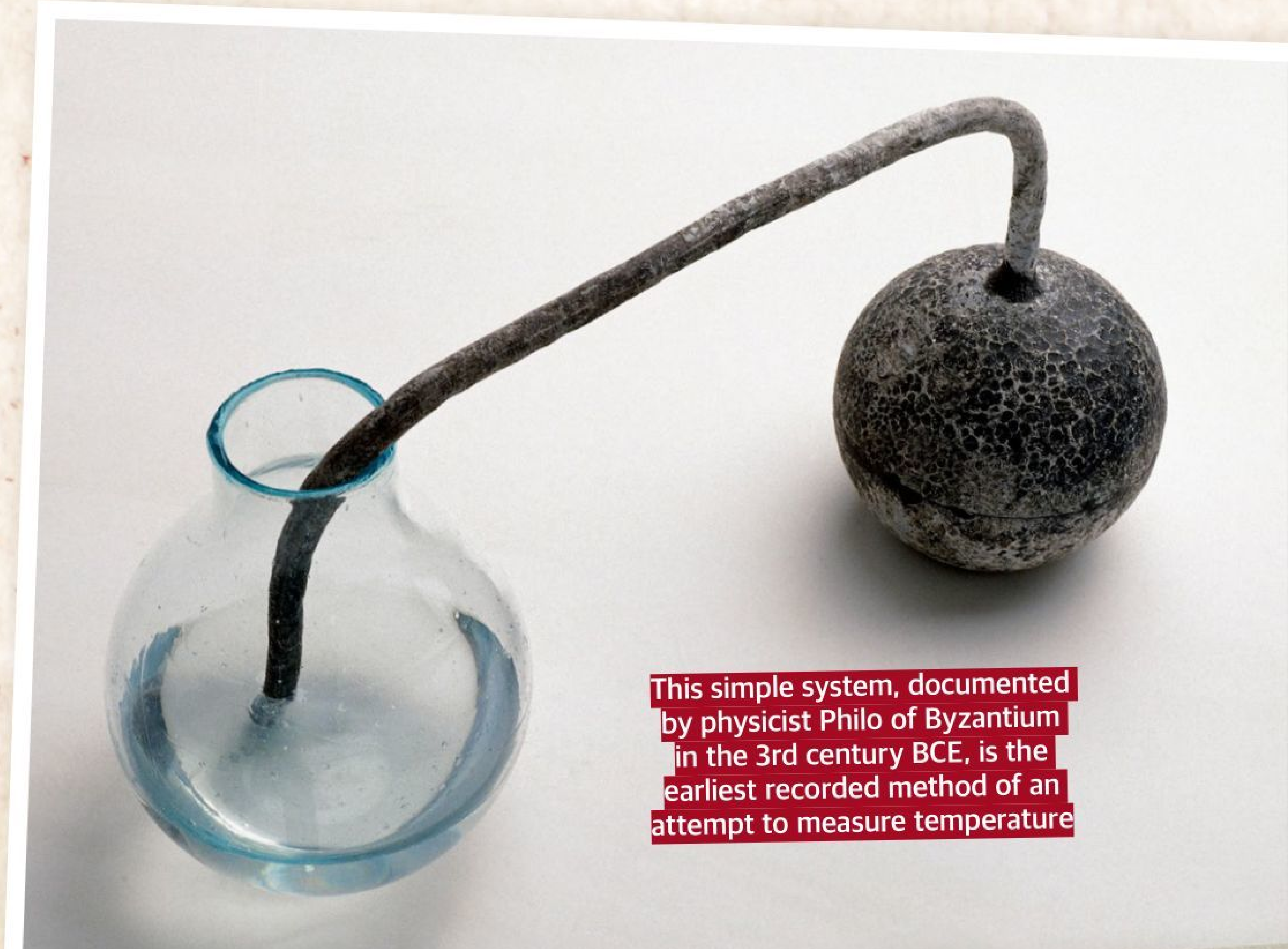
There are many claimants to the title 'inventor of the thermometer', and that's because rather than being a single invention, its development came in several stages over the course over almost 2,000 years. Philo of Byzantium, who lived during the 3rd century BCE, performed the first recorded experiment involving the expansion and contraction of air in different temperatures. He connected a tube between a hollow sphere and a jug of water, and as the air in the sphere cooled and therefore contracted, water rose up the tube from the jug.

In the 16th century, Galileo Galilei, or one of his colleagues, invented the thermoscope. This was very similar to Philo's contraption, but the tube rose up vertically out of the water and the hollow sphere was at the top. Scales were added, but these were not standardised and the devices suffered in that they were also sensitive to air pressure.

Ferdinand II, the grand duke of Tuscany, improved upon their design with the invention of the first sealed glass thermometer. This version consisted of a sealed cylinder filled to a certain height with coloured alcohol. Small glass bubbles filled with air at varying pressures hovered within the liquid, changing positions as the temperature rose or fell.

However, it was Daniel Gabriel Fahrenheit – the inventor of the temperature scale that now bears his name – who created the first reliable 'modern' thermometer in 1714, which used mercury instead of water or alcohol. This could provide a finer scale, and went on to become the standard design for centuries to come.





This simple system, documented by physicist Philo of Byzantium in the 3rd century BCE, is the earliest recorded method of an attempt to measure temperature

Fahrenheit's mercury thermometer was more accurate than any invented before

Ophthalmoscopes, which are used to examine the interior surface of the eye, now feature electric illumination

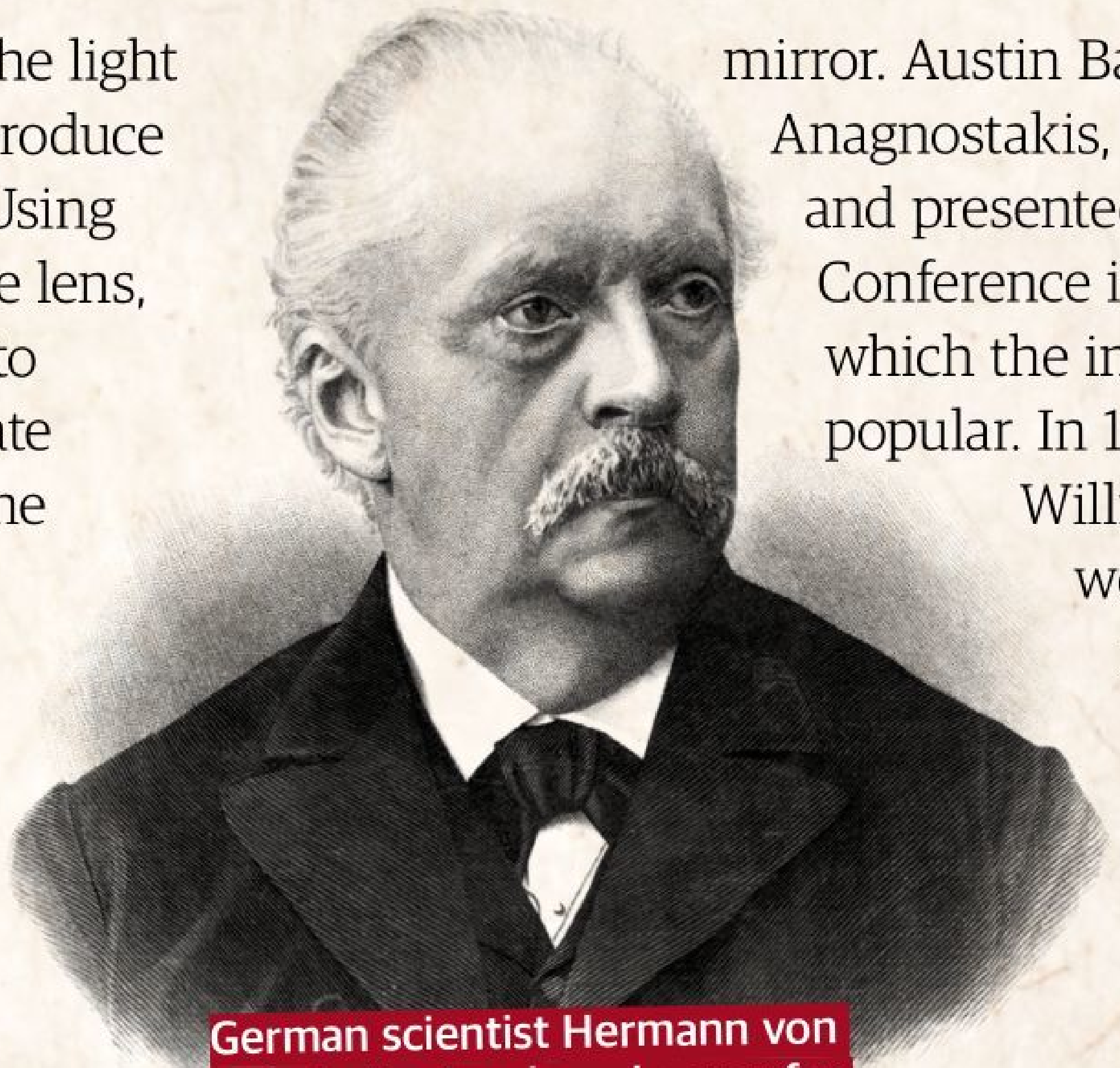
OPHTHALMOSCOPE

Hermann von Helmholtz Germany, 1851

There is so much more to this little device than meets the eye…

The ophthalmoscope is one of medicine's most important instruments. It enables opticians and doctors to closely examine the interior surface of the eye, which is useful not only for accurately prescribing glasses, but can also be used to examine retinal blood vessels and detect high blood pressure and arterial disease. Glaucoma and tumours can also be discovered using an ophthalmoscope. Though the 'father of the computer' Charles Babbage invented an ophthalmoscope of sorts, it was German scientist Hermann von Helmholtz who, following his studies of the human eye, independently invented the one that would be recognised as useful. He noticed that he could focus the light reflected from the retina to produce a sharp image of the tissue. Using reflecting glass and a concave lens, Helmholtz developed a way to enable physicians to illuminate the retina and observe it at the same time.

Andreas Anagnostakis, an ophthalmologist from Greece, came up with the idea of making the instrument handheld by adding a concave mirror. Austin Barnett created a model for Anagnostakis, which he used in his practice and presented at the first Ophthalmological Conference in Brussels in 1857, following which the instrument became very popular. In 1915, Francis A Welch and William Noah Allyn invented the world's first handheld direct illuminating ophthalmoscope. Today, ophthalmoscopes equipped with electric illumination are still used in research and diagnostics.



German scientist Hermann von Helmholtz developed a way for physicians to illuminate the retina and observe it at the same time

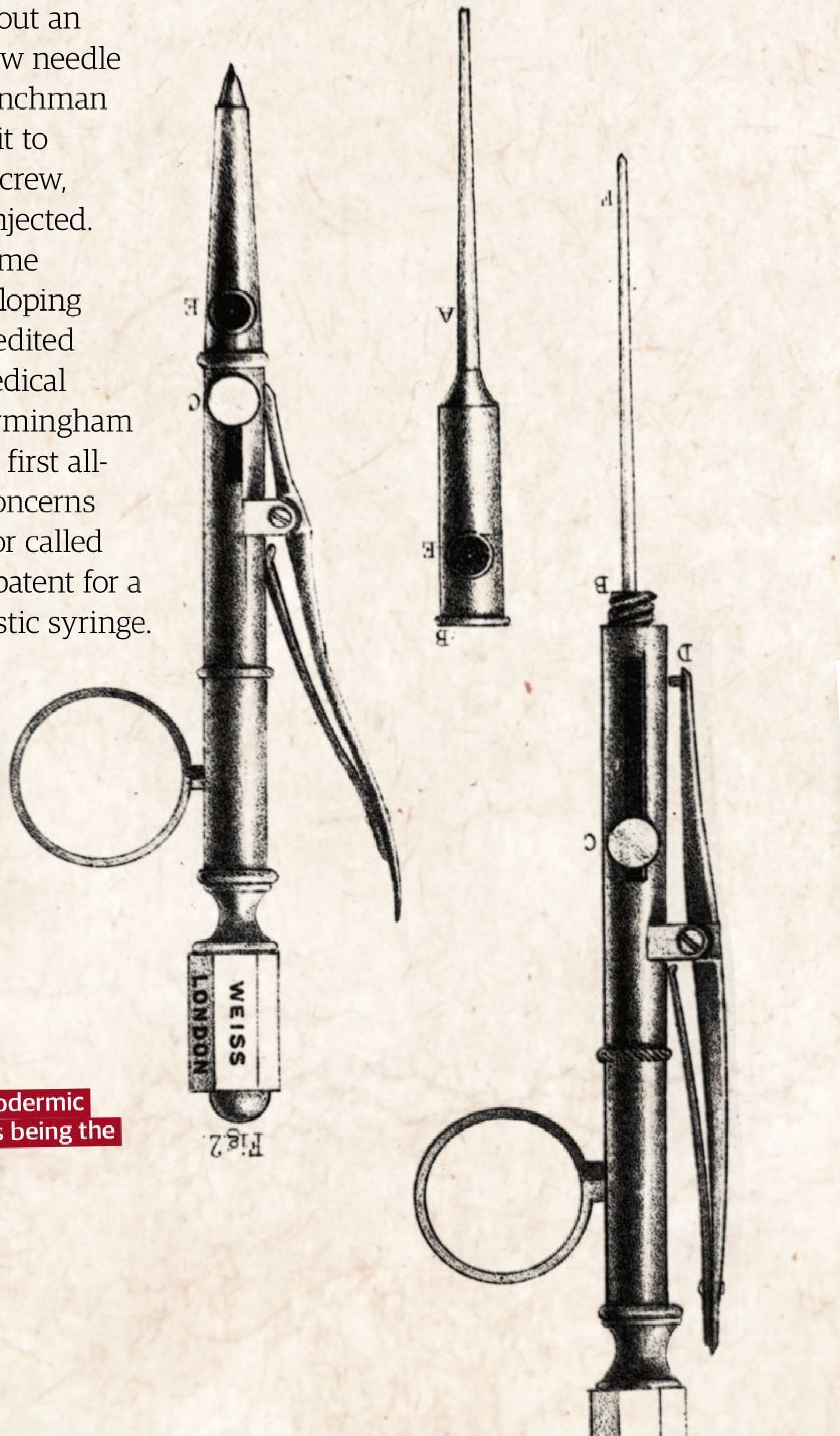
HYPODERMIC SYRINGE

Charles Pravaz or Alexander Wood (disputed) France/Scotland, 1850s

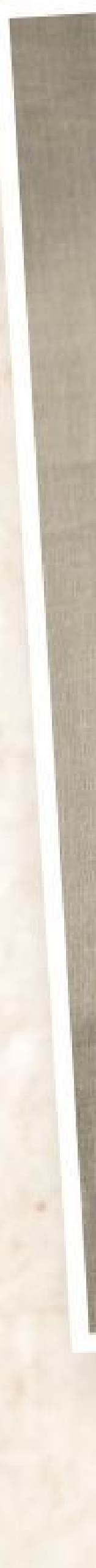
Thanks to the hypodermic syringe, medicines can be administered quickly and safely, but as with most inventions, it's not entirely clear who we have to thank for these life-saving devices

Hypodermic (meaning 'beneath the skin') syringes are used to inject substances into or extract liquids from the body. They consist of a very thin, hollow needle attached to a syringe. Modern needles are designed to reduce contamination in two ways: firstly, their incredibly smooth surfaces prevent germs from sticking to them; and secondly, they are incredibly sharp, which means that only the tiniest hole is left, thereby reducing the chance of infection. However, they haven't always been this high-tech. Christopher Wren was the first to experiment with hypodermic needles in the 17th century, using animal bladders as the syringe and goose quills as the needle. It was impossible to perform injections without an incision until after the invention of the hollow needle by Irish physician Francis Rynd in 1844. Frenchman Charles Pravaz took his design and adapted it to create a hypodermic syringe operated by a screw, which controlled the amount of substance injected. It was made entirely of silver. Around the same time in Scotland, Alexander Wood was developing his own hypodermic needles, and can be credited with the popularisation of injections as a medical technique. By 1944, the Chance Brothers' Birmingham glassworks factory were mass producing the first all-glass syringe and a decade later, following concerns about sterilisation, a New Zealand inventor called Colin Murdoch applied for a patent for a disposable plastic syringe.

Francis Rynd invented the first hollow needle in 1844



The Charles Pravaz hypodermic syringe is often credited as being the first of its kind



A scientist putting together the components for a pacemaker

Before Wilson Greatbatch made his discovery, pacemakers had to be worn externally

PACEMAKER

Wilson Greatbatch USA, 1956

An accidental invention, the pacemaker almost never made it to market, thanks to fears over doctors interfering with nature

The pacemaker has its origins in the 19th century, when Scottish physiologist John Alexander MacWilliam discovered that the application of an electrical impulse to a human heart could force the muscles to contract and pump blood. In the 1920s, a device using that technology was used to revive a stillborn child and in 1932, American Albert Hyman created a version with a hand-cranked motor. However, his research was never published, as the public believed he was interfering with nature by 'reviving the dead'. In the 1950s, external pacing devices were created, but these were bulky and often required mains power. The pacemaker as we know it wasn't invented until 1956. Wilson Greatbatch, an American engineer, was building an oscillator to record heart sounds when he accidentally installed a resistor with the wrong resistance. It began emitting a regular electrical pulse not dissimilar to that produced by a beating heart. He realised that his invention could be used to help a diseased heart stay in rhythm, so over the next two years he perfected his design into a pocket-sized assembly of batteries and resistors.

In 1960, it was implanted into a human patient – a 77-year-old man who went on to live a further 18 months. A patent was granted and Wilson Greatbatch Ltd was created (now Integer Holdings), which still produces pacemaker technology today.

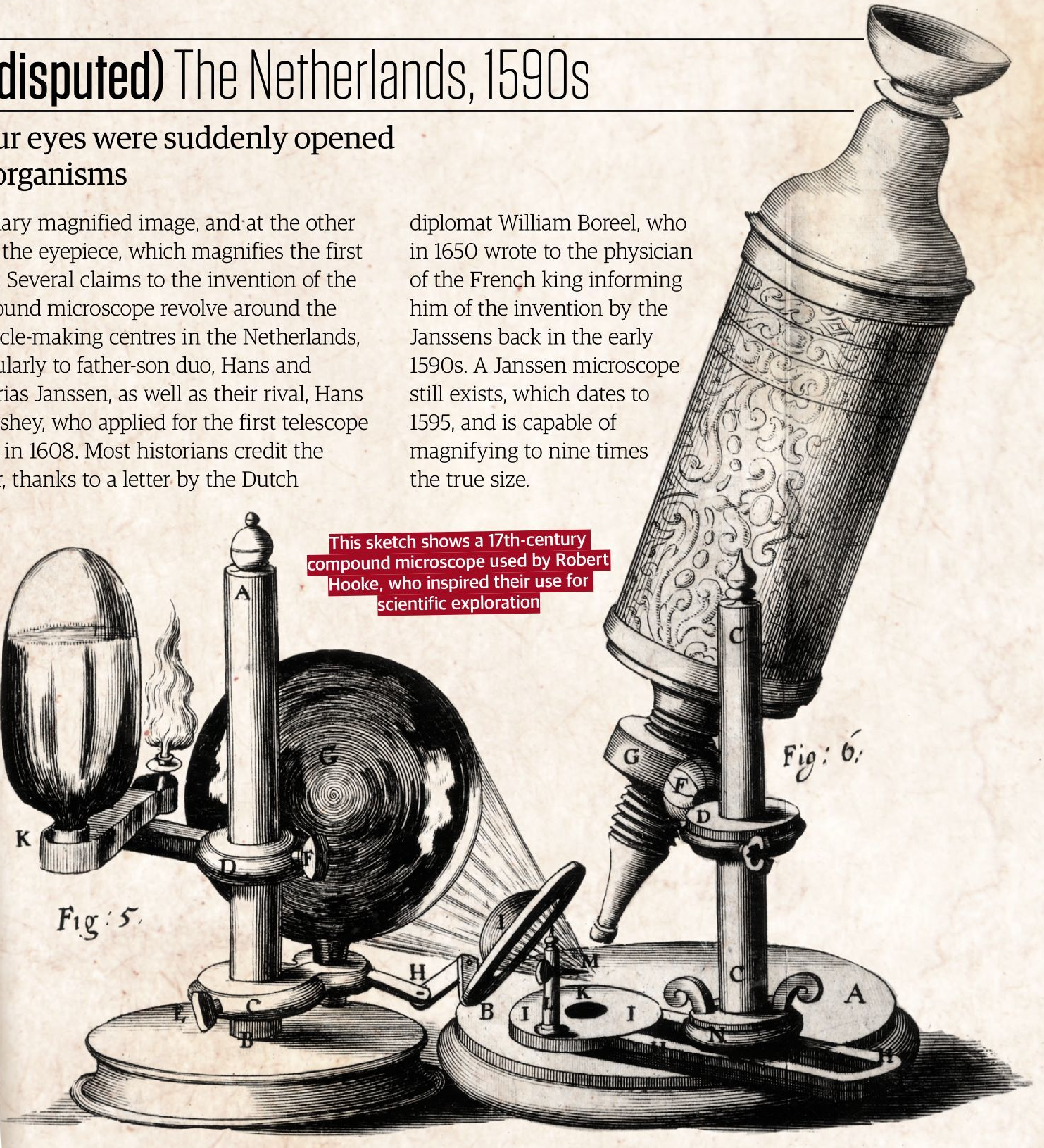
MICROSCOPE

Hans and Zacharias Janssen (disputed) The Netherlands, 1590s

With the invention of the microscope, our eyes were suddenly opened to a whole new world of cells and microorganisms

For millennia, humans were only able to see objects that were at least the width of a human hair. Ancient civilisations had experimented with the optical properties of water and, following its invention circa 3,000 BCE, glass, but it was with the creation of the eyeglasses in the 13th century that simple microscopes were first used. These were essentially magnifying glasses, consisting of a single lens, and were mainly employed in the examination of tiny insects. They came to be known as 'flea glasses'.

But when we talk about microscopes, what we really mean is 'compound microscopes' – consisting of more than one lens connected by a hollow tube. There is an objective lens at the end nearest the specimen, which produces a primary magnified image, and at the other end is the eyepiece, which magnifies the first image. Several claims to the invention of the compound microscope revolve around the spectacle-making centres in the Netherlands, particularly to father-son duo, Hans and Zacharias Janssen, as well as their rival, Hans Lippershey, who applied for the first telescope patent in 1608. Most historians credit the former, thanks to a letter by the Dutch diplomat William Boreel, who in 1650 wrote to the physician of the French king informing him of the invention by the Janssens back in the early 1590s. A Janssen microscope still exists, which dates to 1595, and is capable of magnifying to nine times the true size.



This sketch shows a 17th-century compound microscope used by Robert Hooke, who inspired their use for scientific exploration

A reproduction of a Janssen microscope, which essentially consisted of two lenses connected by a hollow tube

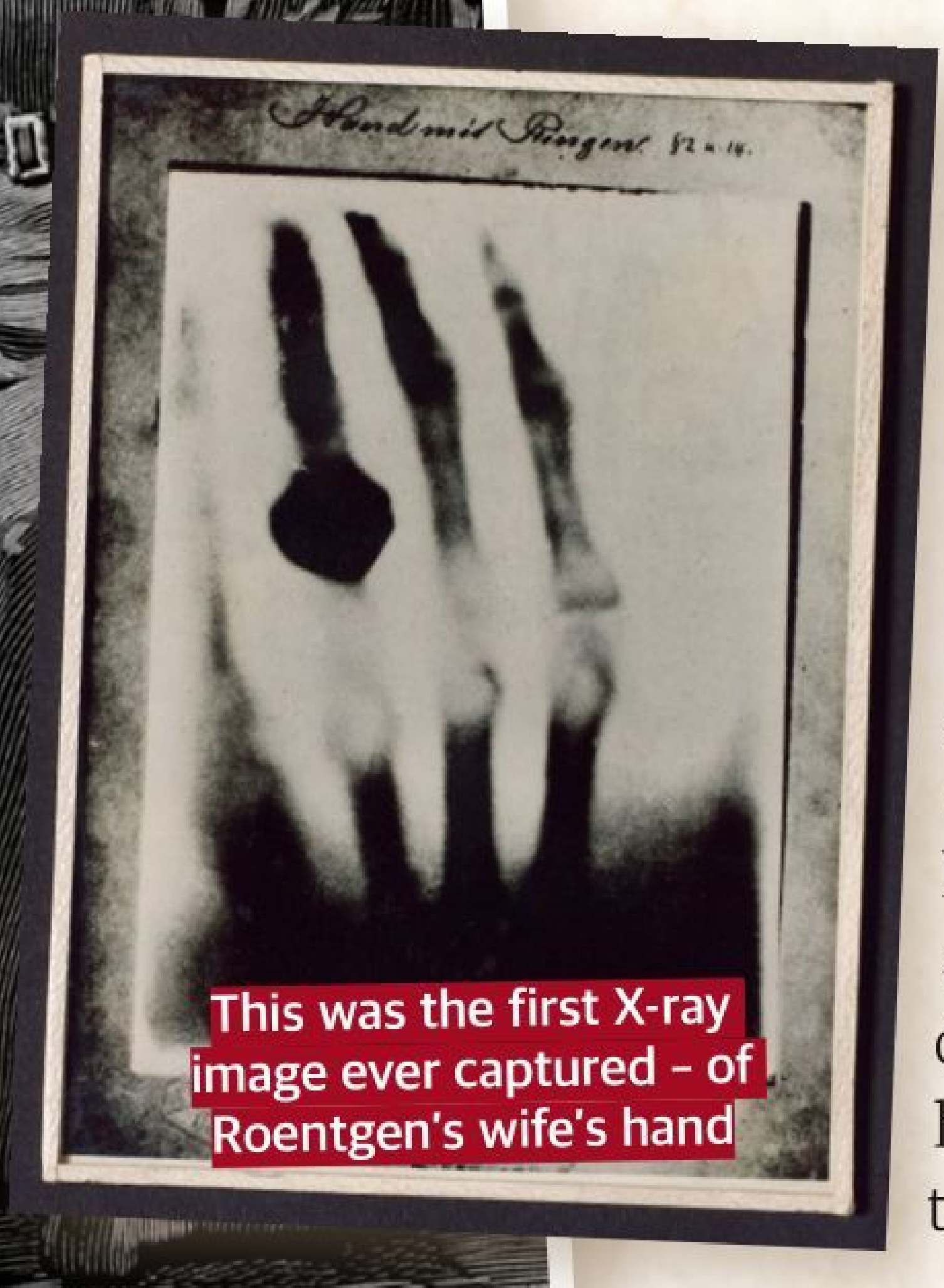
Wilhelm Roentgen discovered X-rays by accident when experimenting with cathode rays

X-RAYS

Wilhelm Conrad Roentgen Germany, 1895

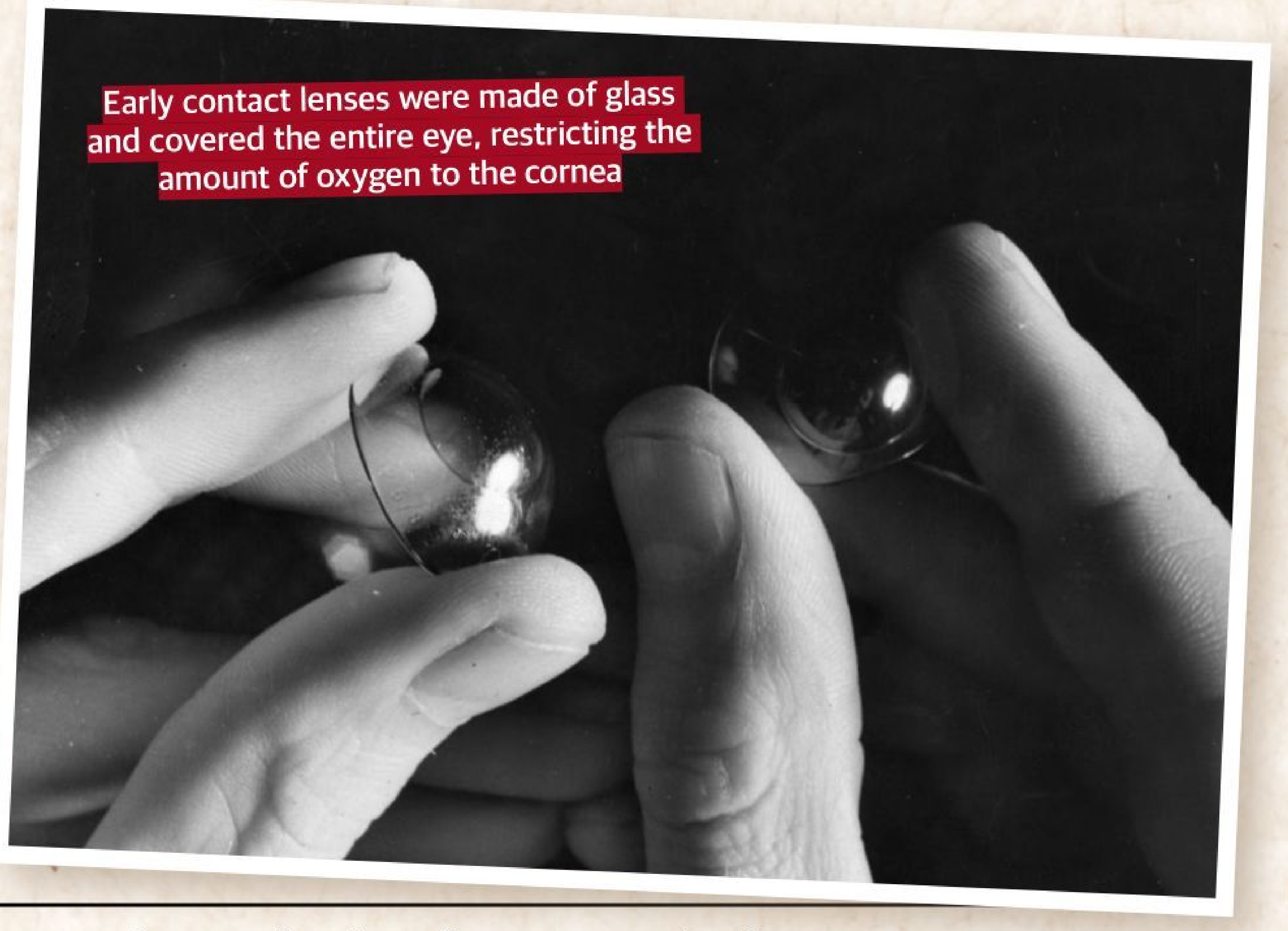
This accidental discovery transformed the lives of doctors – and shoemakers – around the world

Professor Roentgen was famous for his experiments with cathode ray tubes – glass vacuum tubes containing an electron gun. When the electrons hit a fluorescent screen at the other end of the tube, it lights up, and by controlling where the electrons hit, an image can be made. During one of his experiments, he noticed a fluorescent glow was being created on a material located a few feet away from the tube, despite the fact that he had covered the tube with cardboard to stop the light escaping. He realised that a new kind of ray was being created that was capable of passing through the heavy paper. For the next few weeks, he barely left his laboratory as he investigated the many properties of the rays he called 'X-rays'. He discovered that the rays could pass through human tissue, but not through bones and metal objects, and in late 1895 he took his first photograph of a human body part using X-rays – of his wife's hand. Within a month of announcing his discovery, several medical radiographs had been made and were being used by surgeons to aid them in their work. By the 1920s, X-ray machines were being used in shoe shops to help with fittings. However by the 1950s, concerns about the dangers of X-rays led to the end of this practice, although they continue to be used in medical applications to this day.



This was the first X-ray image ever captured – of Roentgen's wife's hand

> "He discovered that the rays could pass through human tissue, but not through bones and metal objects"



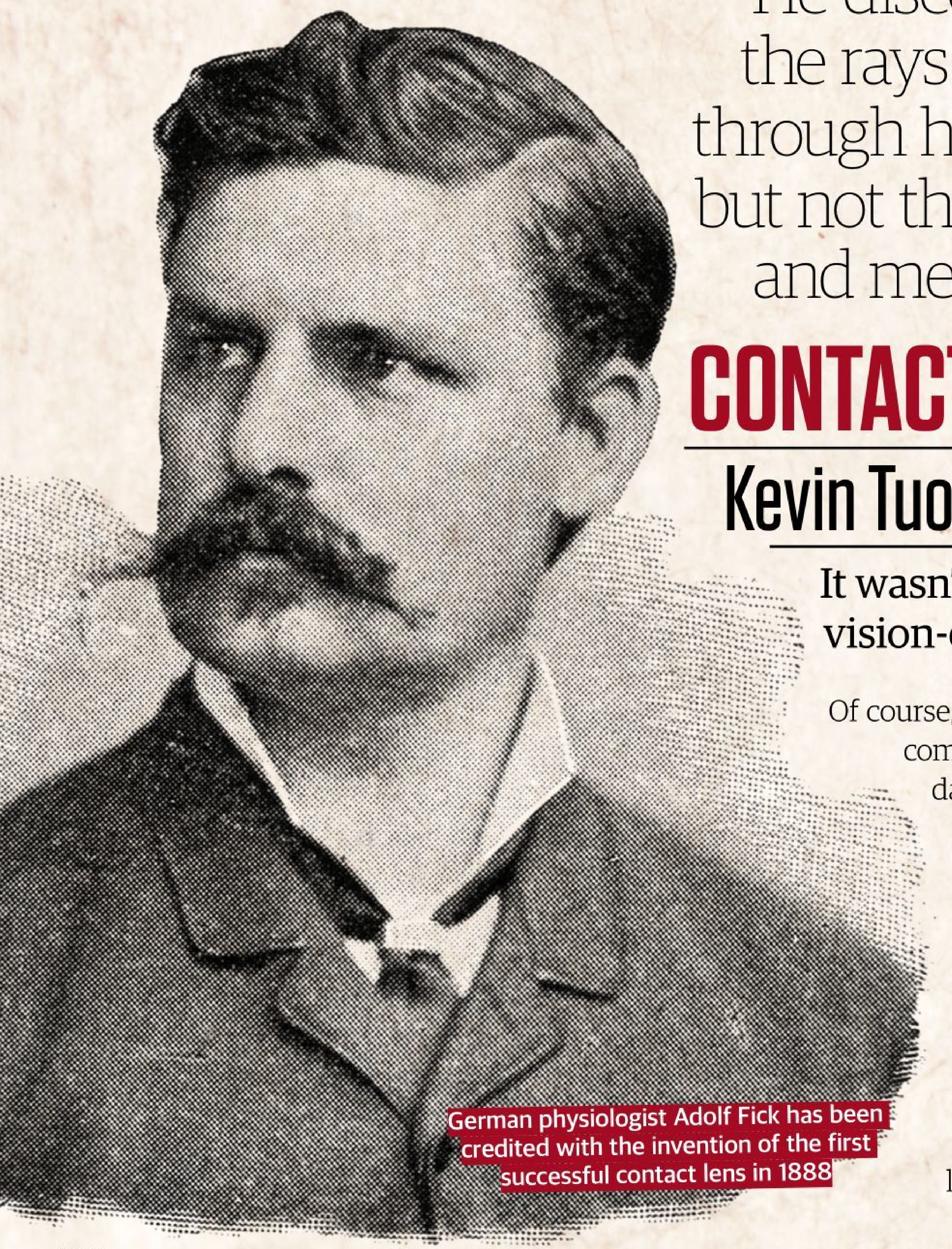
Early contact lenses were made of glass and covered the entire eye, restricting the amount of oxygen to the cornea

CONTACT LENS

Kevin Tuohy USA, 1948

It wasn't until the 20th century that a design for a practical, vision-correcting contact lens was created

Of course, a history of inventions wouldn't be complete without a mention of Leonardo da Vinci – the original Mad Scientist. It was he who in 1508 first suggested that the power of the cornea could be altered by wearing a water-filled glass hemisphere over the eye. But that's about as far as he got. In 1801, another polymath – Thomas Young – brought da Vinci's sketch to life when he used wax to affix water-filled lenses to his eyes. A few decades later, Sir John Herschel proposed an idea for making a mold of the cornea in order to produce conforming glass lenses, but it wasn't until the 1880s that someone actually did this… and there is some debate as to who did it first. German ophthalmologist Adolf Fick was one of the claimants, as was his compatriot, August Muller. Louis Gerard is another name associated with the invention of the first contact lens. Regardless, all three of their designs covered the entire eye, and could therefore only be tolerated for a few hours. It was a Californian optician, Kevin Tuohy, who introduced the first corneal lenses in 1948, which were plastic, gas permeable, and most resemblant of the contact lenses we know today.



German physiologist Adolf Fick has been credited with the invention of the first successful contact lens in 1888

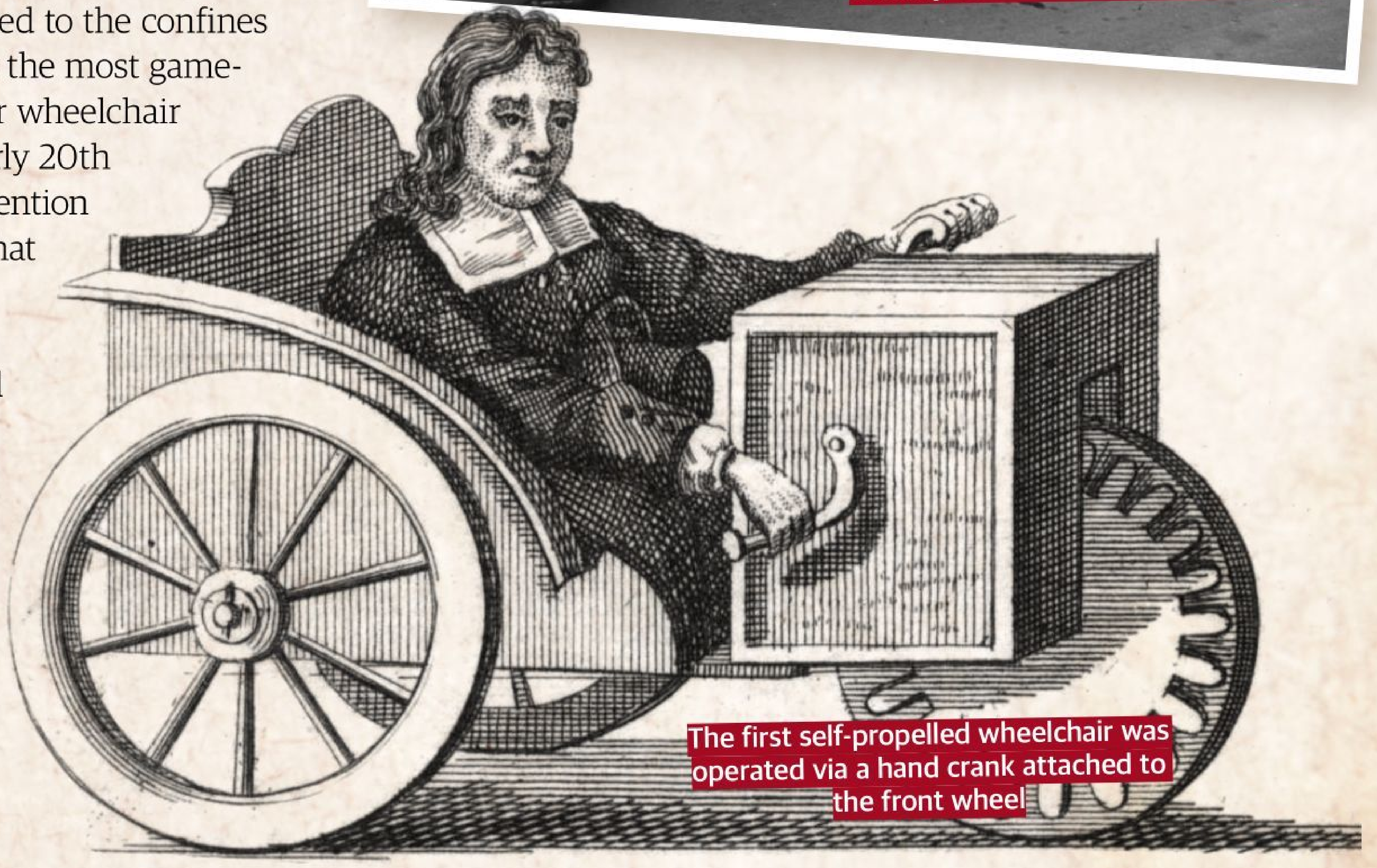
Designed for use by the disabled, bath chairs were popular among the wealthy as a relaxed form of transport

WHEELCHAIR

Stephan Farffler Germany, circa 1650

Though they date back to ancient times, it was a disabled watchmaker who revolutionised the wheelchair's design

No one knows when wheeled chairs were first used by disabled people. It's likely that it happened around the same time that wheeled furniture was introduced, in the 6th century BCE, but the first surviving records of its occurrence don't appear until 3rd-century BCE China. Meanwhile, the first recorded use of self-propelled chairs by disabled people in Europe dates to the 17th century. These were invented by a German paraplegic watchmaker called Stephan Farffler and consisted of a three-wheeled, one-person carriage that had hand cranks on the front wheel. However, contrary to their initial purpose, 'invalid chairs' were mainly used as a form of transport by the wealthy. In 1750, James Heath invented the 'bath chair', which featured a folding hood and was pushed or pulled by hand (or, in some cases, by a donkey or horse). These were followed by wooden-framed seats that eventually featured wire-spoke wheels and rubber tyres, but independent use was usually limited to the confines of the home. Perhaps the most game-changing moment for wheelchair users came in the early 20th century, with the invention of a folding version that enabled outdoor use. The developments that followed focused on reducing weight and improving functionality until eventually, following World War II, the first electric wheelchairs were introduced.



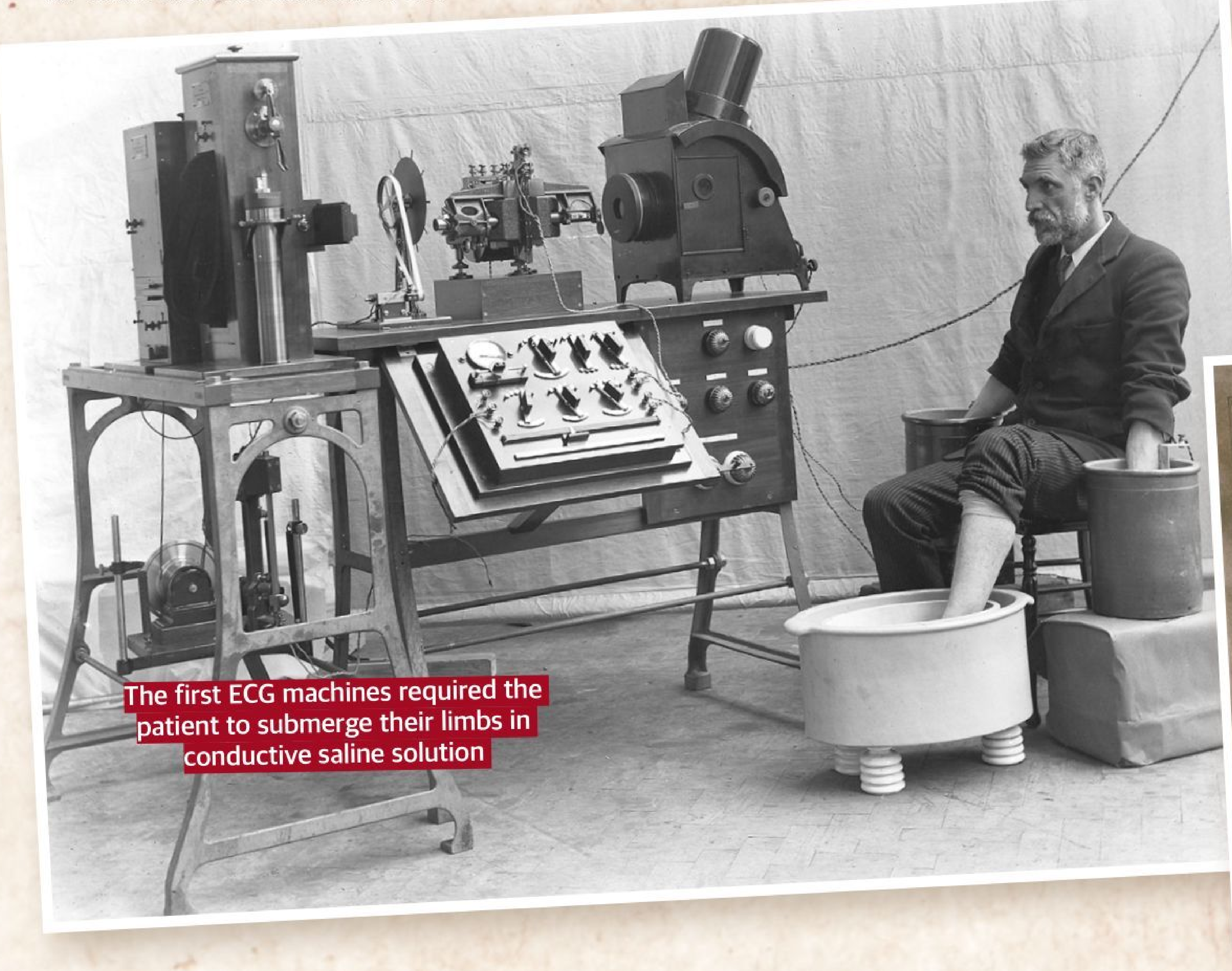
The first self-propelled wheelchair was operated via a hand crank attached to the front wheel

ELECTROCARDIOGRAPH

Willem Einthoven The Netherlands, 1903

We now know them as the hospital machines that display those characteristic peaks and troughs, but ECGs haven't always measured heart activity so accurately

Animal electricity (galvanism) was discovered by Italian scientist Luigi Galvani in 1786, following an experiment on a dead frog. He observed that when the legs were touched by a copper probe and a piece of iron at the same time, they twitched, just as if an electric current were present. Carlo Matteucci built on his work in the 19th century, becoming the first to detect electrical activity in the heart. However, this tiny current was very hard to record and measure. The problem was solved by British physiologist Augustus Desiré Waller, who used a Lippmann electrometer to produce the world's first ECG machine. This device featured a tube of mercury – a liquid that conducts electricity. When a current from the heart was applied, it caused the mercury to leap up the tube. The change could then be observed through a microscope and photographed. This machine was extremely inaccurate and cumbersome, but a Dutchman named Willem Einthoven witnessed it in action and resigned himself to produce a practical version. He did this using a string galvanometer, which he had invented in 1901, combined with a rotating bicycle. His first prototype weighed 270 kilograms, required five people to operate, and demanded the patient be submerged in vats of conductive saline solution. But the results were astounding. Over the years he improved upon his design, with the development of electrodes eliminating the need for the saline solution. It became invaluable for diagnosing heart conditions and in 1924, he was awarded a Nobel Prize.



The first ECG machines required the patient to submerge their limbs in conductive saline solution

Electrogram traces taken by August Waller between 1887 and 1903

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FIRST HUMAN HEART TRANSPLANT

3 DECEMBER 1967

Louis Washkansky sits up in bed following his successful heart transplant surgery, the first of its kind in history. Surgeon Christiaan Barnard performed the nine-hour long procedure at the Groote Schuur Hosptial in Cape Town, South Africa. Sadly, Washkansky died just 18 days later following treatment to suppress his immune system so that the heart was not rejected, leaving him susceptible to pneumonia.

© Getty Images

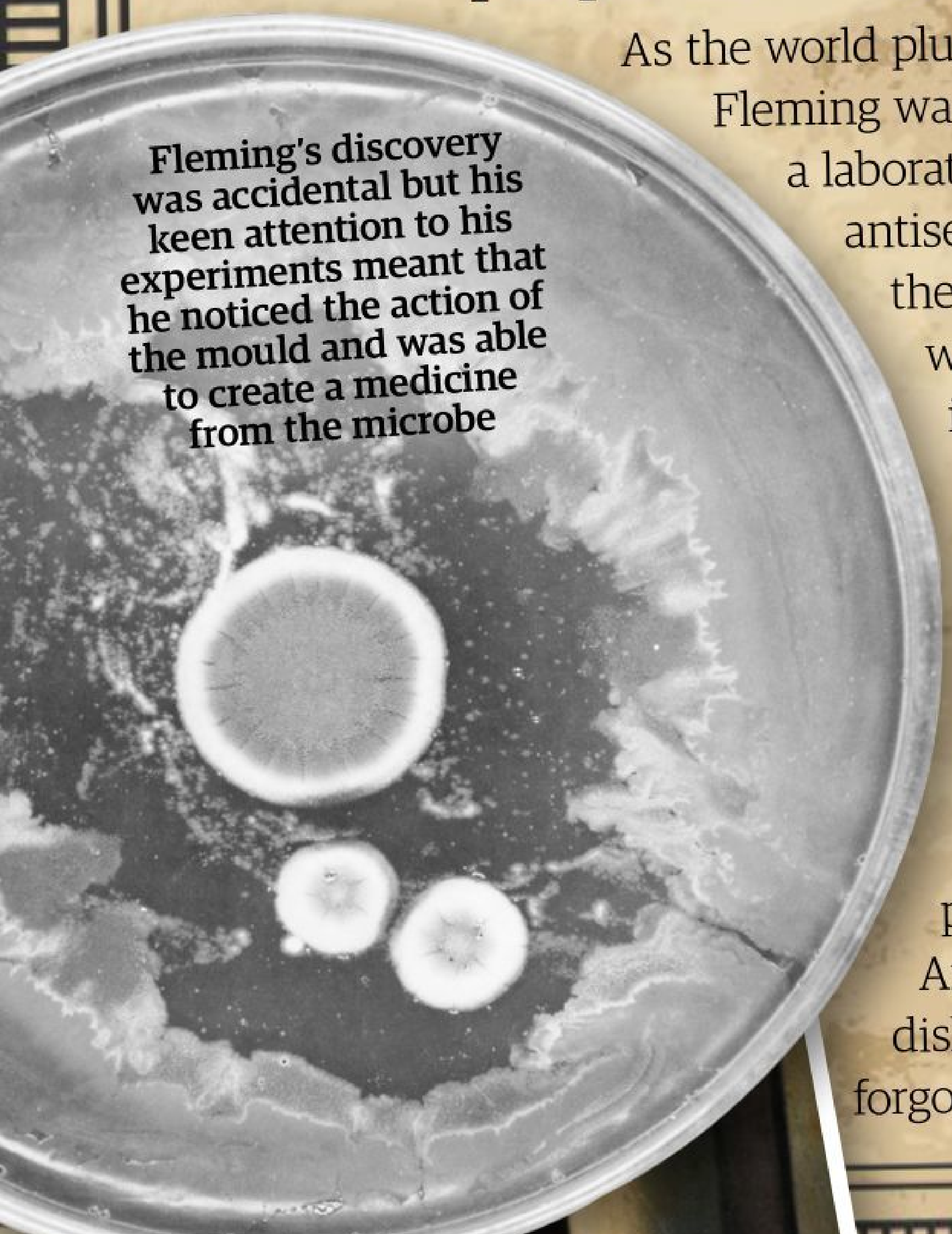
THE GREATEST MEDICINES EVER DISCOVERED

From chemotherapy to contraception, the creation of these medications and the pioneers behind their development changed the course of history

PENICILLIN

Alexander Fleming St Mary's Hospital, London, September 1928

An accidental discovery led to the production of a drug that has saved more people than any other medicine in history



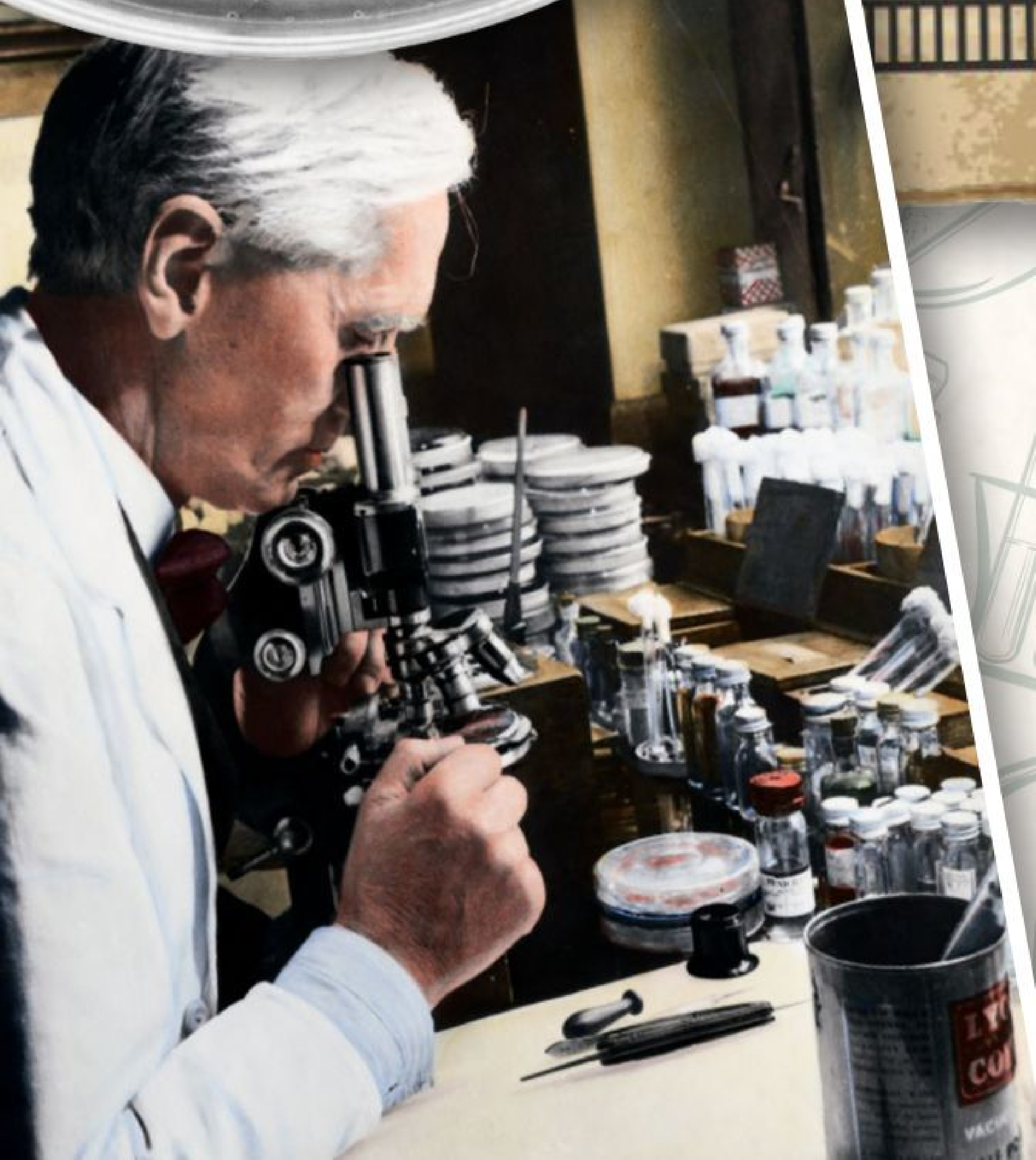
Fleming's discovery was accidental but his keen attention to his experiments meant that he noticed the action of the mould and was able to create a medicine from the microbe

As the world plunged into the Great War, Alexander Fleming was starting his work in wound research at a laboratory in Boulogne. He was frustrated that antiseptics could not prevent gangrene for the seriously injured soldiers, as shrapnel was forcing clothing and debris deep into the tissue that antiseptics couldn't penetrate. Seeing the soldiers suffer and die from septicaemia, tetanus, and gangrene ignited his passion on leukocytes and antisepsis, and he started investigating staphylococcus, a bacteria that caused boils and systemic infections that were fatal for patients with weak immune systems.

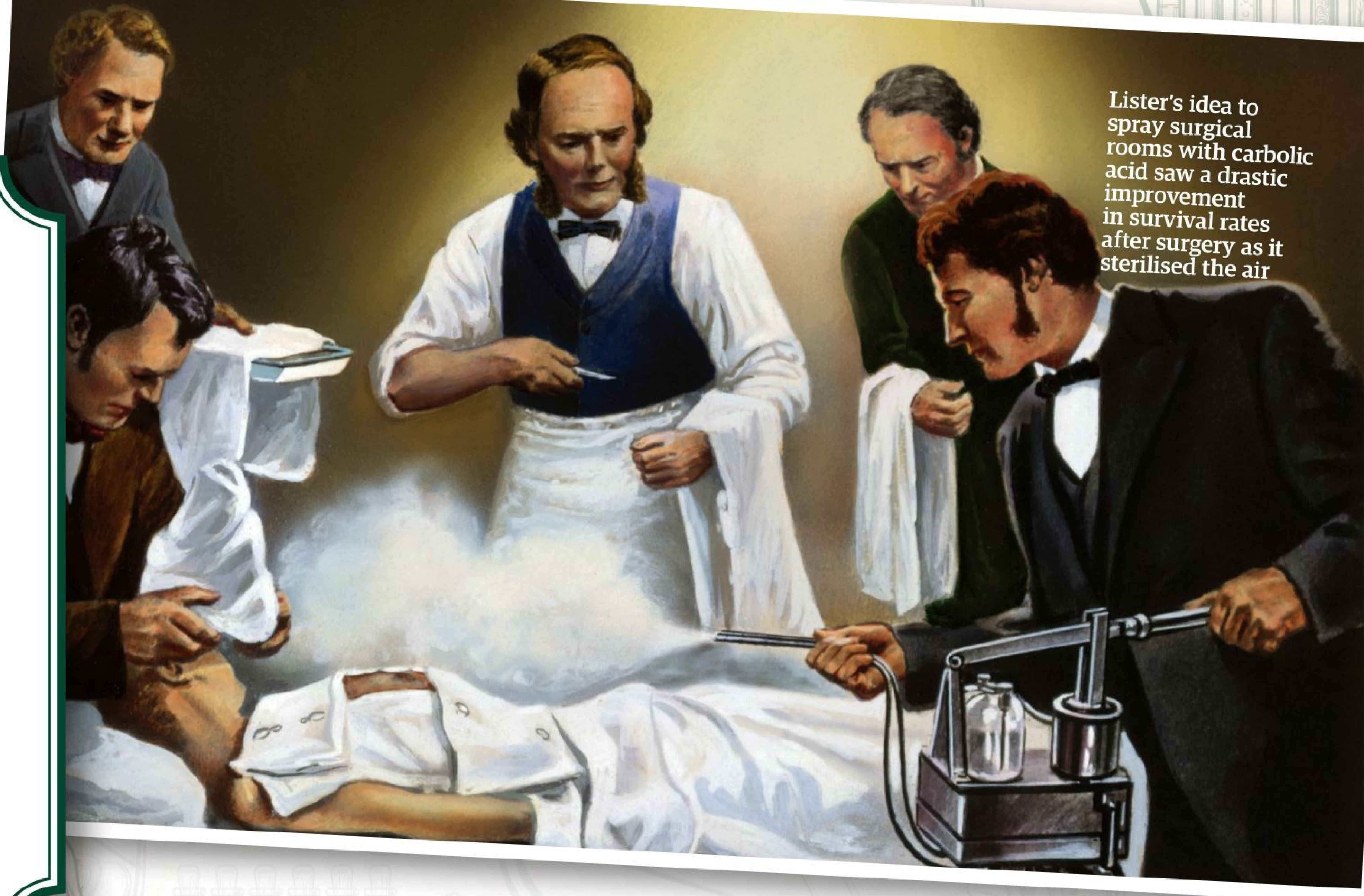
After growing the bacteria on Petri dishes, Fleming left for a vacation and had forgotten to incubate the sample.

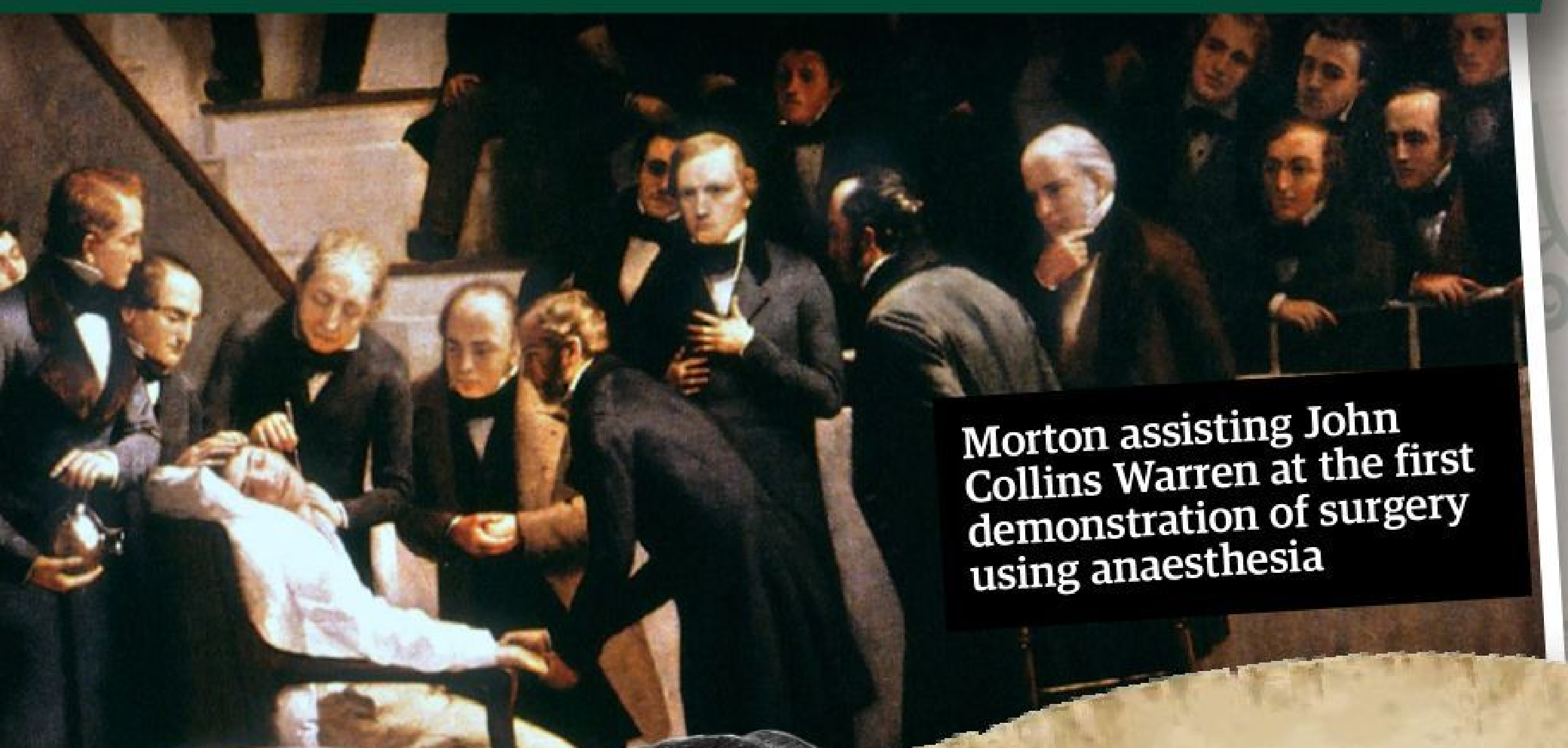
When he returned from France, the bacteria had grown as usual but some areas had been destroyed around mould spores that had accidentally been introduced into the dish. The mould thrived in the room temperature environment but would have been killed by the higher temperatures of an incubator, so the action of the microorganisms had never been observed before. He identified the mould as belonging to a family known as Penicillium. It wasn't until World War II that Howard Florey and Ernst Chain managed to properly isolate and concentrate the mould into a usable mass-produced antibiotic, but all three men won the Nobel Prize in 1945 for the discovery and development.

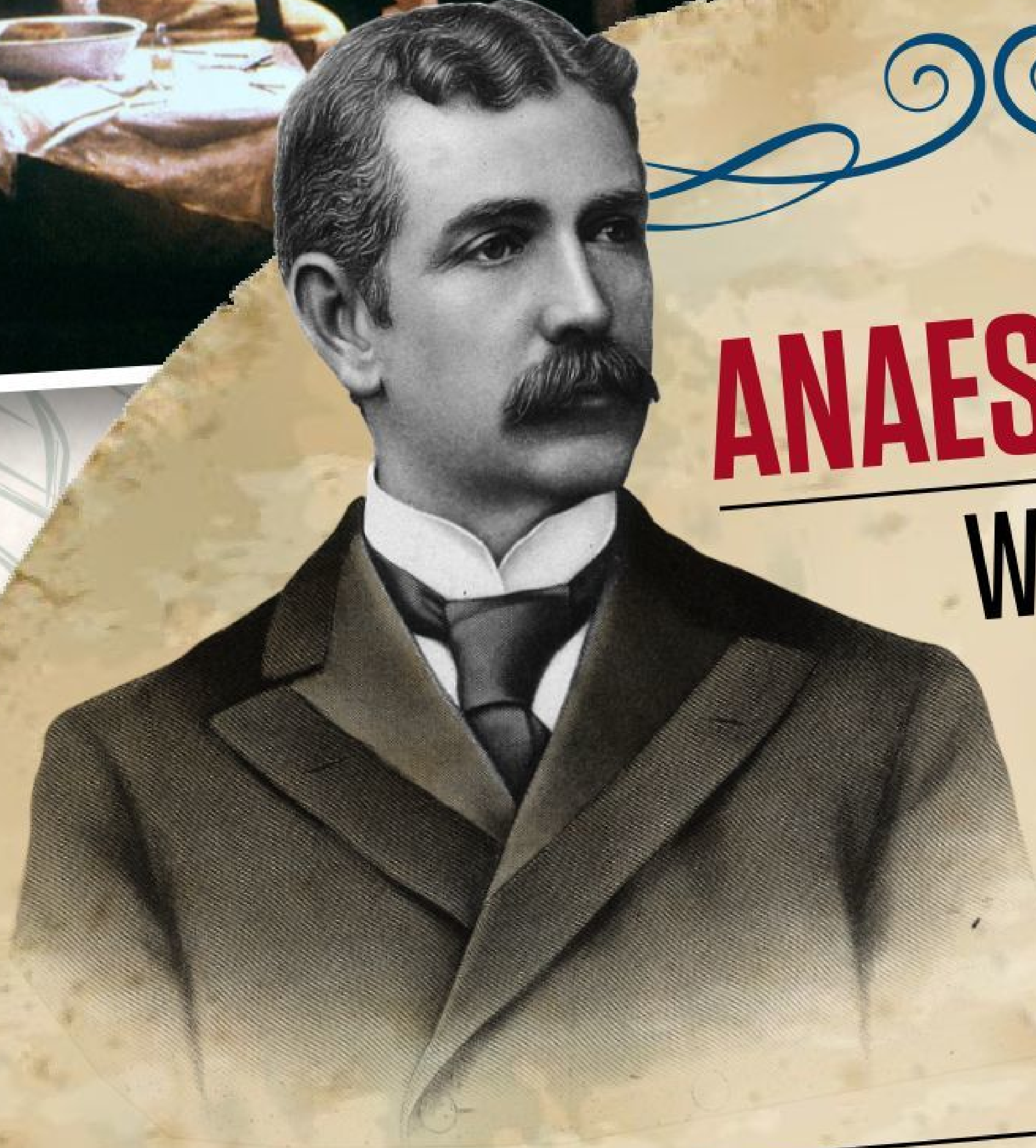
It has been estimated that without the invention of this incredible drug, 75 per cent of the people alive today wouldn't be here, because their parents, grandparents, or great-grandparents would have died from an infection.



Our broken bones are wrapped in plaster, aggressive chest infections are defeated with antibiotics, and throbbing headaches are subdued with a couple of paracetamol popped out of the packet. We no longer need to fear childbirth or a broken bone, but for most of human history just a simple cut on your hand could have been a death sentence. The last 200 years have seen the eradication of diseases that have plagued our species since the foundation of civilisation, the development of drugs to tackle cancer, and preventative medicine that means we no longer need to fear deadly microbes. These drugs changed the entire practice of medicine, how we understand disease, and saved the lives of millions.


Lister's idea to spray surgical rooms with carbolic acid saw a drastic improvement in survival rates after surgery as it sterilised the air


Morton assisting John Collins Warren at the first demonstration of surgery using anaesthesia



ANAESTHETIC

William TG Morton Massachusetts General Hospital, Boston, United States, 16 October 1846

Painless surgeries marked a breakthrough in patient treatments and enabled more complex procedures

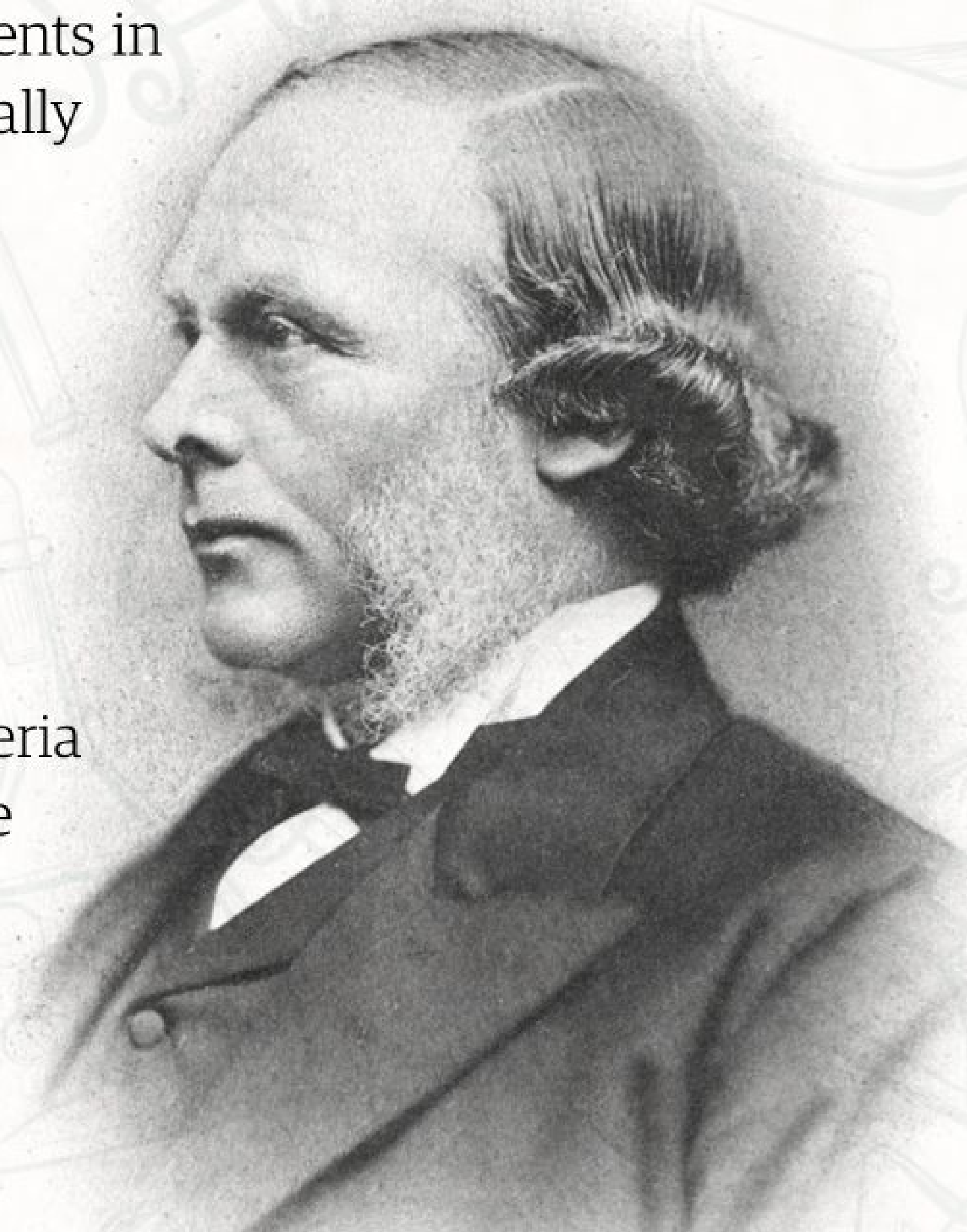
Surgery before the discovery of anaesthetic was a gruesome affair – patients had little choice than to drink strong alcohol and be forcibly restrained onto a hospital bed. If people were lucky they might have had access to opium or herbs like mandrake to offer some relief from the excruciating pain. But everything from limb amputations to mastectomies to bladder stone removals were all carried out with the patient fully conscious. Often faced with the choice of agonising surgery or certain death, there was no choice other than to hope for a surgeon who was swift with the scalpel. It wasn't until 16 October 1846 that William TG Morton's research saw the first surgical demonstration using a real anaesthetic. He had experimented with different chemicals to find one that rendered the patient unconscious so they were unable to move or feel pain while the procedure was being carried out. His chemical of choice was ether gas, successfully given to a patient to inhale, before painlessly removing a tooth. Morton then assisted Dr John Collins Warren in the first demonstration to use anaesthetic, removing a tumour from a man's neck. It soon became common for surgeons to experiment with ether, and doctors continue to use inhaled gases today.

ANTISEPTIC

Joseph Lister Glasgow Royal Infirmary, Scotland, 12 August 1865

The revolution to sanitise hospitals marked a change in hospital infrastructure that dramatically increased survival rates and transformed surgical practices

Our hospitals today come with a familiar smell of detergent. It's not a pleasant scent, but it offers comfort that the environment is clean. We take it for granted, but hospitals were not always this hygienic. Surgeries were once carried out with the air and surfaces swarming with bacteria. Patients would have a simple injury or undergo a minor surgery, only to succumb to postoperative infection within days. Joseph Lister had been present at the first surgical procedure carried out by Morton, and was aware of Louis Pasteur's research on microorganisms. He formed his own theories and started experimenting with chemicals with the theory that they could kill the germs before they could infect a patients healing wound. He began soaking dressings in carbolic acid and noticed an immediate reduction in the mortality rate on the ward. Lister then took his idea even further – he started washing his hands, dousing his instruments in acid, eventually spraying the solution into the air while he operated. It seems common sense now but at the time it wasn't recognised that bacteria were the reason for the high mortality rate of patients after surgery. Lister is now recognised as the 'father of antiseptic surgery'.



The first contraceptive pill was marketed to help relieve gynaecological problems but was used off the record to prevent unplanned pregnancies

SMALLPOX VACCINE

Edward Jenner Gloucestershire, England, 14 May 1796

An ancient disease that we have battled since the beginning of human history was eradicated thanks to one physicians' pioneering method

Smallpox plagued humans from prehistory and the mission to defeat variola eventually led to the first successful eradication of a disease. The distinctive smallpox rash was the first symptom of the deadly virus as it destroyed tissue and crushed the immune system, leading to painful raised skin lesions filled with thick fluid in a matter of days. The luckiest of patients would survive the incident but most survivors were left with disfiguring deep pitted scars. There was no cure and it usually claimed its victims in less than two weeks until British physician Edward Jenner started his research on developing a vaccine. His work not only led to the prevention of smallpox in millions of people, but formed the basis of the life-saving vaccines that are available to us today. The English countryman was aware of the folklore that said milkmaids didn't catch smallpox. But Jenner noticed they would catch a similar virus from the cows known as cowpox. In 1796, he extracted the pus from a cowpox blister, cut the arm of a young boy and pushed the fluid into the wound. When the child was later exposed to smallpox, Jenner found that he was immune. Jenner realised it was possible to create a preventative vaccination by inducing an immune response to a similar, but less deadly disease. Scientists had yet to discover viruses, but Jenner's forward-thinking solution meant that he was still able to solve the problem despite not fully understanding the mysterious microbes.

Thirty years after his death in 1823, the smallpox vaccination was made compulsory, with the finally being globally eradicated by 1980.

Inoculation with a safer, similar virus meant the immune system was tricked into producing antibiotics that would protect against the more deadly disease

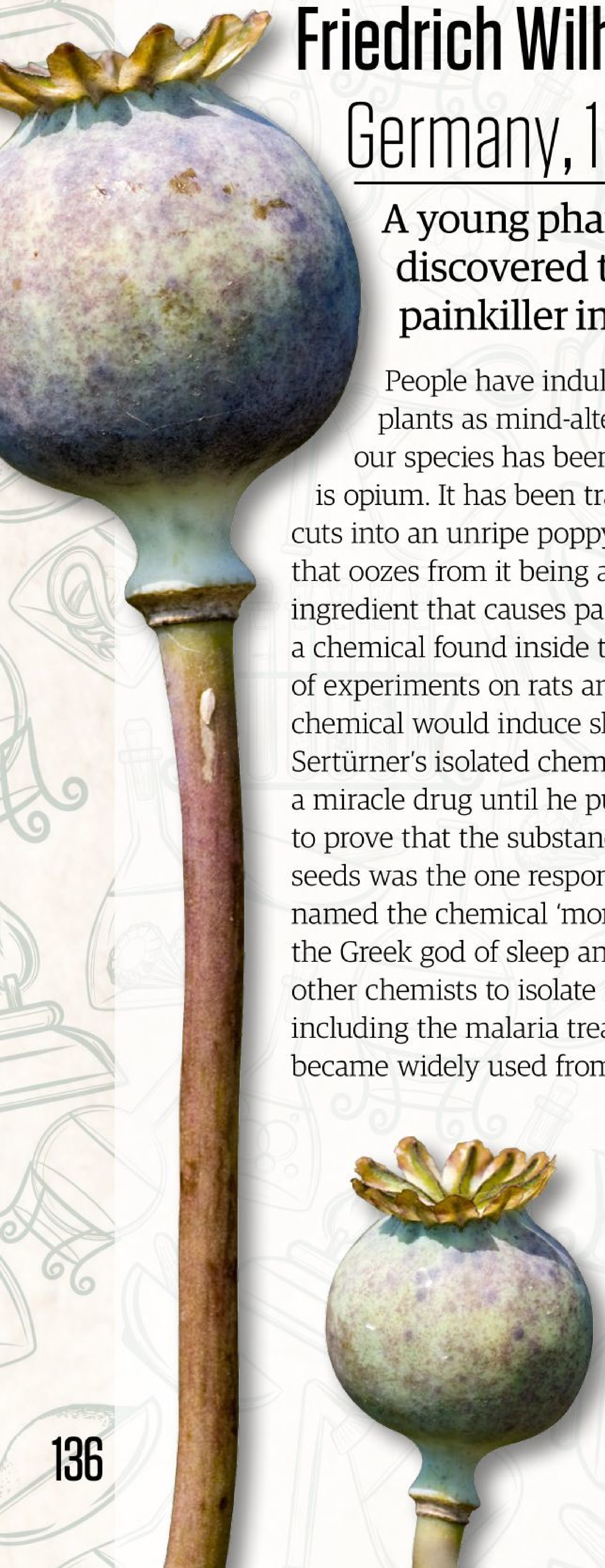
MORPHINE

Friedrich Wilhelm Sertürner

Germany, 1803-04

A young pharmacist apprentice discovered the world's greatest painkiller in a poppy seed

People have indulged in the recreational use of plants as mind-altering substances for as long as our species has been in existence. One of these drugs is opium. It has been traditionally harvested by making cuts into an unripe poppy seed pod, with the milky gum that oozes from it being air dried into a powder. The active ingredient that causes pain relief and euphoria comes from a chemical found inside the plant. Sertürner started a series of experiments on rats and stray dogs and found that the chemical would induce sleep. But his findings went ignored. Sertürner's isolated chemical would not be welcomed as a miracle drug until he publicly experimented on himself to prove that the substance he could extract from poppy seeds was the one responsible for the effects of opium. He named the chemical 'morphine' – named after Morpheus, the Greek god of sleep and dreams. The discovery inspired other chemists to isolate compounds of medical importance, including the malaria treatment quinine. The pharmaceutical became widely used from 1815 for pain relief.



The development of morphine came from understanding an old herbal preparation that was used as a recreational drug before its application in pharmacy

ASPIRIN

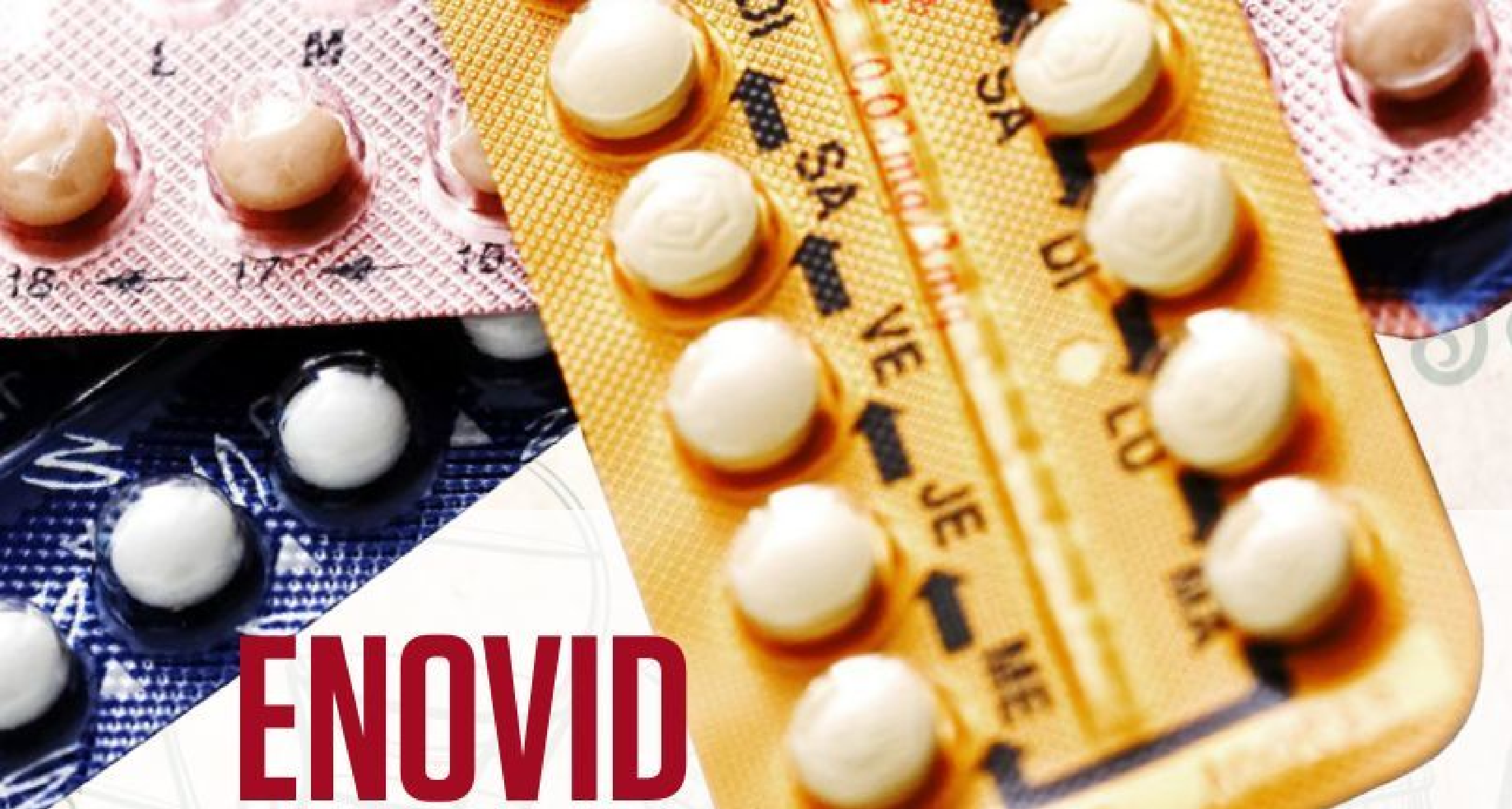
Felix Hoffmann

Bayer, Germany, 1897

The most widely used painkiller and blood thinner came about from researching an ancient natural remedy

Willow bark has been used as a natural treatment of pain since the ancient Greeks, but it wasn't for thousands of years before physicians would have the technology to isolate the active compound responsible for its therapeutic effects. French pharmacist Henri Leroux managed to isolate the chemical, salicylic acid, in 1829 but it would be almost 50 years before the painkiller could be synthesised. The aspirin we use today to remedy everything from a headache to the common cold was developed in the late 1890s by Felix Hoffman at Bayer in Germany. He had been investigating the chemical and produced acetylsalicylic. This compound kept the original active ingredient from willow bark but eased the nausea and vomiting that were common side effects of the drug in its pure form. Hoffman used it to help treat his father's rheumatism before Bayer began distribution of the medicine in powder form in 1899. It was a quick success, and by 1915 was sold as over-the-counter tablets.

Aspirin is now used all over the world to provide mild to moderate pain relief



ENOVID

Margaret Sanger and Gregory Pincus

Worcester Foundation in Massachusetts, 10 June 1957

The first birth control pill was a landmark in women's rights

The simple contraceptive pill marked a turning point in society by giving women the right to choose if they wanted to have children. It meant women had the chance to decide to further their education or focus on their career, and they were no longer expected to stay home and raise and family while men went out to work. Today the pill has prevented millions of unplanned pregnancies. The first hormonal birth control pill available on the market was Enovid. It was the work of a joint effort and large-scale collaboration with great minds including Katharine McCormick, John Rock, Syntex, Min Chueh Chang and SA Laboratories, but the idea and creation came from Margaret Sanger and Gregory Pincus through the Worcester Foundation in Massachusetts. The innovation had been driven by activists who wanted a better solution to family planning, particularly after the depression, when many people were living in poverty and struggling to feed their children. Sanger and McCormick were at the front of the fight to give women a way to improve their lives and more rights over their decisions. The team experimented and conducted clinical trials in rabbits using two compounds, norethynodrel and norethindrone, before starting human trials in the 1950s. The pill was a resounding success and within a couple of years was marketed for gynaecological disorders. It was finally accepted and marketed explicitly as a contraceptive in June 1960.

The fight for women's liberation wasn't over, because it was initially only prescribed to married women, but it marked the beginning of an upheaval of society and started a snowball of research into developing synthetic hormones.

Margaret Sanger popularised the term 'birth control' and opened the first birth control clinic in the US in 1916

Industrial-scale chemical reactors were used to manufacture mustard gas at Edgewood Arsenal, Maryland, USA, during World War I

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MECHLORETHAMINE

Alfred Gilman Sr and Dr Louis Goodman

Yale School of Medicine, 27 August 1942

Once a chemical used on the frontline of warfare, this drug was taken into the battle against cancer

In July 1917, German forces first deployed their vicious attacks using chemical gas. Troops in Ypres, Belgium, were suddenly shrouded in a cloak of peppery smelling gas. It penetrated their clothes, permeated their lungs, and caused internal bleeding in addition to the blisters on skin contact. The thick oily mustard gas would leave entire battlefields contaminated, but under the cloak of wartime secrecy in World War II, scientists started investigations into the chemical. They observed that naval personnel exposed to the noxious gas had changes in their bone marrow that caused abnormally low levels of white cells. Louis Goodman and Alfred Gilman formulated a hypothesis – if the gas could kill healthy white blood cells, it must also be able to kill cancerous ones. Up until this point in history, cancer patients were faced with the grim chances offered to them by surgery and radiation, but Dr Goodman wanted to see if nitrogen mustard could open new doors for patients whose tumours had become resistant or were not responding. He tested the gas on a patient known as 'JD', who was dying of advanced lymphoma – his tumours had grown so large he was unable to cross his arms. He agreed to the experimental treatment and at 10am on 27 of August 1942, was injected with the gas. He received a number of treatments and with each he started to recover, being able to eat and sleep for the first time. Nitrogen mustard paved the way for further investigation and development into novel anticancer drugs and chemotherapy became a standard treatment.

THORAZINE

Paul Charpentier

Rhône-Poulenc Laboratories, France, 11 December 1951

The first psychiatric medication saw the start of a new era in the treatment of mental illness

There is now a vast array of medicines that can help relieve the symptoms of mental illness

The 1950s were the advent of psychiatric medication. It was a time where mental health started being taken seriously and treatments were developed to help people struggling with these illnesses. One of the medicines born of this revolution were antipsychotics, the first of which was chlorpromazine. French pharmaceutical company Rhône-Poulenc were investigating antihistaminergic agents for treating allergies when Paul Charpentier first synthesised the drug Thorazine (chlorpromazine). But Henri Laborit, a surgeon and researcher, observed the drug working in an unprecedented way. He noticed that the drug was calming his patients before surgery, which led to the decision to further investigate it as a treatment in psychiatry. Jean Delay and Pierre Deniker of St Anne's Hospital in Paris administered it to inpatients at the mental health unit for those suffering with mania and schizophrenia. Their first published papers on the compound in 1952 reported that it controlled agitation without causing sedation. It became the first widely used antipsychotic and is still one of the most effective medicines in the health system.

INSULIN

Frederick Banting and Charles H Best

Toronto, Canada, 1921

The discovery of insulin brought people back from the brink of death and would give diabetics a normal life in the decades following.

Sir Frederick Banting extended the life expectancy and the quality of life of diabetics after his discovery of insulin

Diabetes was once a feared illness that would inevitably lead to death. The only effective treatment before the discovery of insulin was for patients to effectively starve themselves to reduce sugar intake. The difficult treatment would give the patient a few extra years, but they would be malnourished, tired, and in pain. It was known from 1869 that pancreas damage caused diabetes and it was soon discovered that the pancreas produces substances that control the level of sugar in the body.

But it wasn't until October 1920 that doctor Frederick Banting started trying to find an antidiabetic secretion from the pancreas. He began working with a medical student, Charles Best, and they started experimenting under the University of Toronto, using basic equipment and experimental dogs. They observed the removal of the pancreas of one of the dogs caused an increase in blood sugar and the classic signs of diabetes – it was thirsty, urinating more, and becoming weaker. Banting and Best surgically removed the pancreas of another dog, ground it into a mixture of water and salts and injected it into the dog with no pancreas. The dog's symptoms were quickly relieved and they realised it could live a normal life if they kept administering the injections. They developed a method to purify the insulin and began testing in humans, self-experimenting with the additional help of Bertram Collip. In January 1922, a 14-year-old boy was bought back from the brink of death using the insulin injections. As soon as 1923, the firm was producing enough insulin to supply the entire North American continent. There is still no cure for diabetes, but this incredible discovery gives diabetics the chance to live an almost normal life.

EMBRYONIC STEM CELLS

Gail Martin

San Francisco, USA, 1981

The discovery that scientists can take cells and transform them into any type of tissue is an advancement that offers to help repair or replace damaged organs

Human embryonic stem cells are one of the great medical discoveries that have inspired scientists around the world. Their application in medicine is almost limitless because the immortal cells are able to differentiate into any type of tissue – from heart muscle to liver or blood. Once harvested and grown, scientists can use them to grow organs, test new drugs, or inject them into patients to help rebuild their tissues. Gail Martin was the first to devise a protocol for isolating and maintaining stem cells taken from tumours and she worked out how to keep them in their undifferentiated state or differentiate them in vitro. The discovery was groundbreaking and led to the isolation of embryonic stem cells from mice. There are several treatments already approved that use this incredible discovery, including bone marrow transplants and blood stem cell transport that helps patients recover and rebuild their blood cells after cancer treatments. The FDA has approved several human trials to start testing embryonic stem cell therapies, and it is expected that the future will see stem cells treating many diseases from Alzheimer's to leukaemia, with clinical trials currently seeking to investigate their effectiveness at healing spinal cord injury and replacing damaged tissue after a heart attack.

Embryonic stem cells are pioneering treatments for transplant and cancer patients

POLIO VACCINE

Jonas Edward Salk

University of Pittsburgh, USA, April 1952

An outbreak of a crippling childhood disease drove researchers to find a preventative vaccine

Poliomyelitis was once one of the most feared diseases in the world. Though there is no cure, the solution to saving people from the illness was creating a preventative vaccine. The painful and contagious virus causes nerve injury, loss of reflexes, and muscle wasting, but thanks to one pioneer the disease is almost eradicated in the West. It was following the 1952 US outbreak when 20,000 were left with paralysis at the hands of polio, that a new type of vaccine would be created and prevent the death and suffering of millions. By 1955, $67 million had been provided into research in the US as scientists became focussed on ending the destructive path of the virus, but working on a vaccine with a live virus was unsuccessful and dangerous. Jonas Salk had been working on building a working virology laboratory and started experimenting with a safer killed virus, rather than attempting to experiment with milder strains. He started on one of the largest clinical trials in medical history, involving over 100 million contributors and more than 7 million volunteers, and the inactive vaccine was announced as safe on 12 April 1955.

Polio mostly attacks children and causes severe paralysis and deformities

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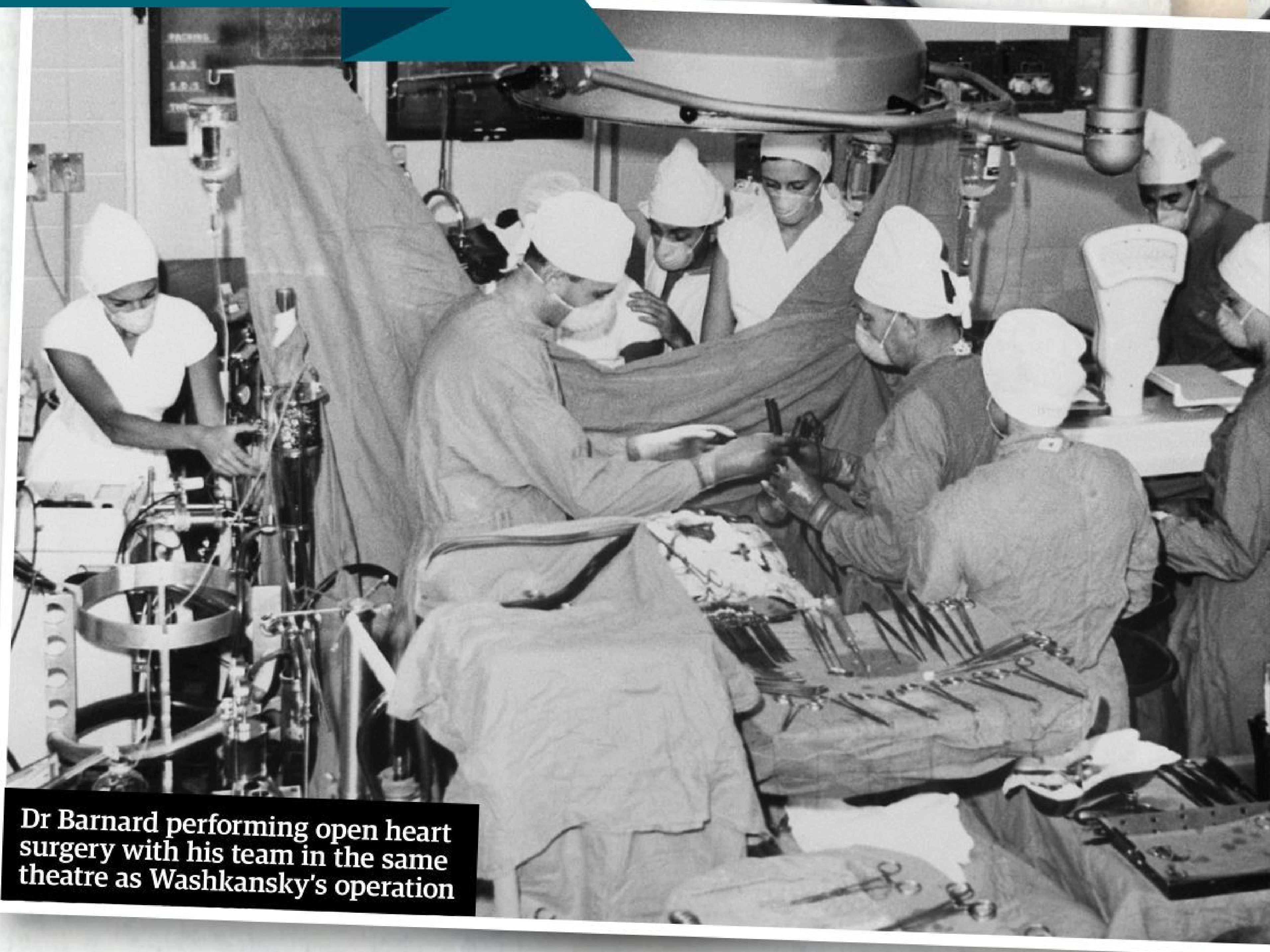
MEDICAL FIRSTS IN HISTORY

From medical journals to the world's first human heart transplant, discover the origins of some of the greatest medical innovations in history

HUMAN HEART TRANSPLANT

Christiaan Barnard Groote Schuur Hospital, Cape Town, South Africa, 1967

Although heart transplants were initially seen as ethically controversial, they have revolutionised treatment for patients with serious cardiac problems



Dr Barnard performing open heart surgery with his team in the same theatre as Washkansky's operation

During the first half of the 20th century, great strides were made in organ transplantation. By the late 1960s, successful kidney, pancreas and liver transplants had taken place, but heart transplants continued to be unsuccessful - until 1967.

The world's first ever successful human heart transplant, over 50 years ago, made medical history, performed by surgeon Christiaan Barnard and his team. Louis Washkansky, a 53-year-old man terminally ill with heart failure, received the new heart. The donor was Denise Darvall, a 25-year-old woman who had lost her life in a car crash.

Washkansky became the first man to regain consciousness after a heart transplant but unfortunately, he died from pneumonia 18 days later. More heart transplants were performed over the next couple of years, but poor survival rates led to their decline around the world.

In 1979, cardiac surgeon Terence English performed the UK's first transplant with long-term success, and transplants were on the rise again during the 1980s. The discovery of ciclosporin, an immunosuppressant helped to change the game as it prevented the body from rejecting a new heart, although the drug had serious side effects.

Heart transplants are performed throughout the world today, with new achievements still being made. For example, the world's first adult non-beating heart transplant occurred in Sydney in 2014 - the possibility of using non-beating hearts could potentially increase the hearts that are available for transplantation.

MOTORISED AMBULANCE

Unknown Chicago, United States, 1899

At the turn of the 20th century, the invention of the motor unit revolutionised patient transportation, both at home and on the battlefront

A convoy of motorised ambulances pictured outside Buckingham Palace in the midst of WWI

Horse-drawn 'modern' ambulances had been used since the 18th century, but it wasn't until 1899 that the first-ever motorised ambulance arrived and was put into service. Used by the Michael Reese Hospital in Chicago, the following year New York City also started using a motorised ambulance for patient transportation.

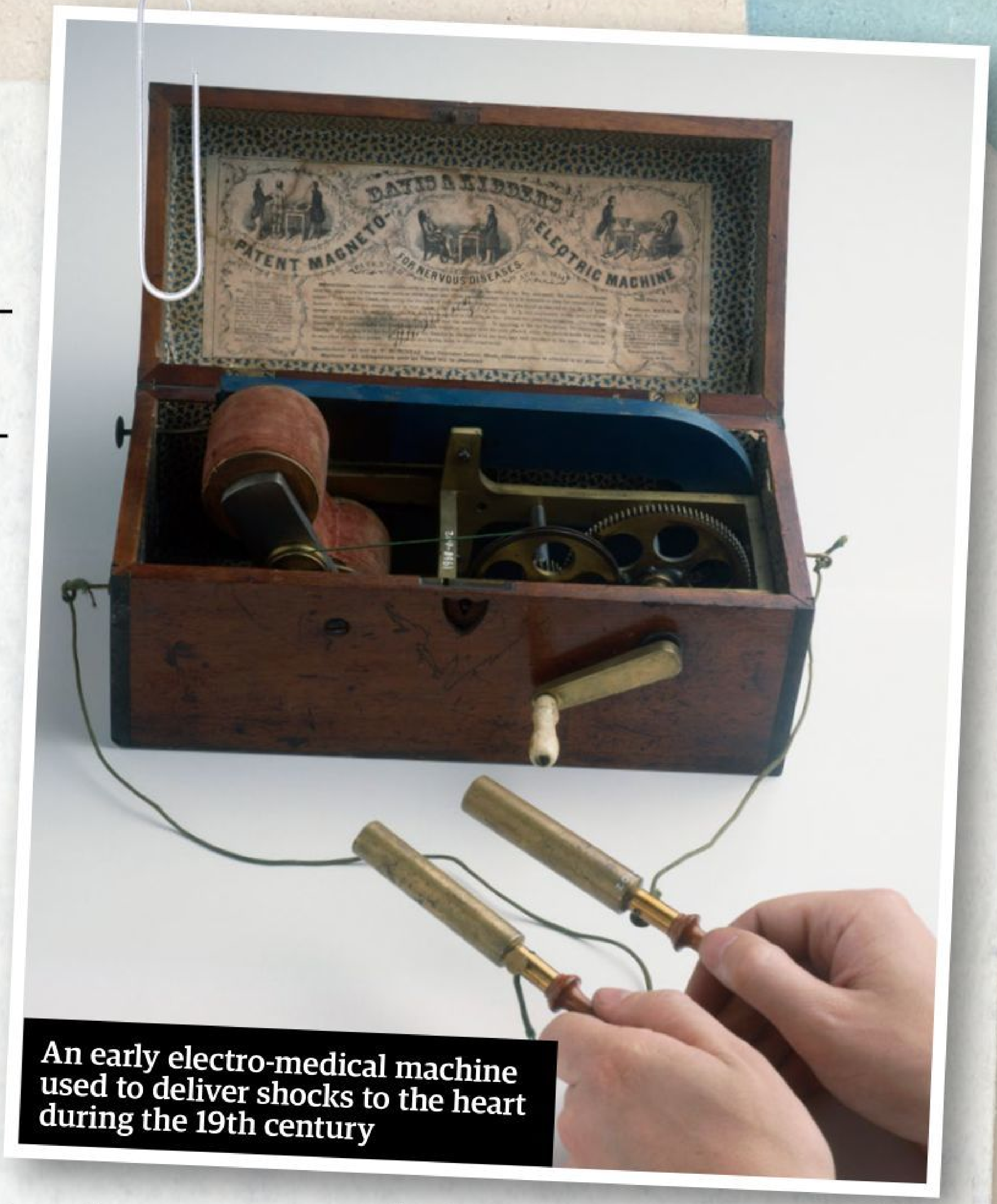
The motorised ambulance was popular because it could move at a greater speed to transfer the patients, as well as being more secure for them. Soon new types of ambulances were being commissioned, such as the three-wheeled Palliser ambulance, powered by gasoline, used in Canada, as well as the ones created for the Royal Army medical corps in 1905.

The motorised ambulance had been put into mass production by 1909. They were first introduced to the battlefield during WWI, to replace the old, horse-drawn versions. As the war progressed, ambulances started carrying more and more equipment and afterwards, the two-way radio was installed to improve radio dispatch.

DEFIBRILLATOR

William Kouwenhoven United States, 1930

The invention of the defibrillator has proved essential in saving the lives of countless people who have suffered a sudden cardiac arrest



An early electro-medical machine used to deliver shocks to the heart during the 19th century

Physiologists Jean-Louis Prévost and Frédéric Batelli first demonstrated the concept of the defibrillator, in Switzerland, 1899. They did this by testing their theory that small electrical shocks could disturb the rhythm of the heart, using dogs. In doing so, they also discovered that larger charges of electricity could reverse an arrhythmia of the heart.

By the 20th century, the idea of defibrillation had evolved into an invasive method. Dr Albert Hyman and C Henry Hyman invented the Hyman Otor, where an insulated wire was delivered through a hollowed needed to give an electrical shock to the heart.

However, the defibrillator - as we know it today - was invented by William Kouwenhoven in 1930. A professor of engineering at John Hopkins University, Kouwenhoven's research focused on the effects electricity had on the human body. Through his work, he became interested in developing a medical instrument that could revive the heart without invasive surgery.

His initial tests on animals proved to be a failure but he continued to experiment on dogs. After a few years, he discovered that delivering a second counter shock to a dog suffering with a cardiac arrhythmia actually restored the heart to its normal rhythm. His experiment successful, Kouwenhoven's discovery of defibrillation changed medical science in cardiology.

In 1947, the first successful use of the defibrillator on a human heart occurred, using the open-chest method. By the 1950s the closed-chest method had emerged, enabling the electric shocks to be delivered to the heart through the chest cage.

By the start of WWII, motorised ambulances were staffed with a doctor and advanced medical equipment. However, as the army desperately needed doctors, the number that travelled with ambulances fell significantly. Other vehicles such as vans and cars, not purpose-built like the ambulance, were also used as demand increased for vehicles to transport patients.

After the 1950s, ambulances evolved so that they could carry more modern equipment, such as the defibrillator and in the 1970s the structure of the ambulance was redesigned. Today, ambulances are full of specialist medical equipment to support the paramedics and crew, as they are expected to deliver more advanced medical care.

MEDICAL JOURNAL

Thomas Basset England, 1684

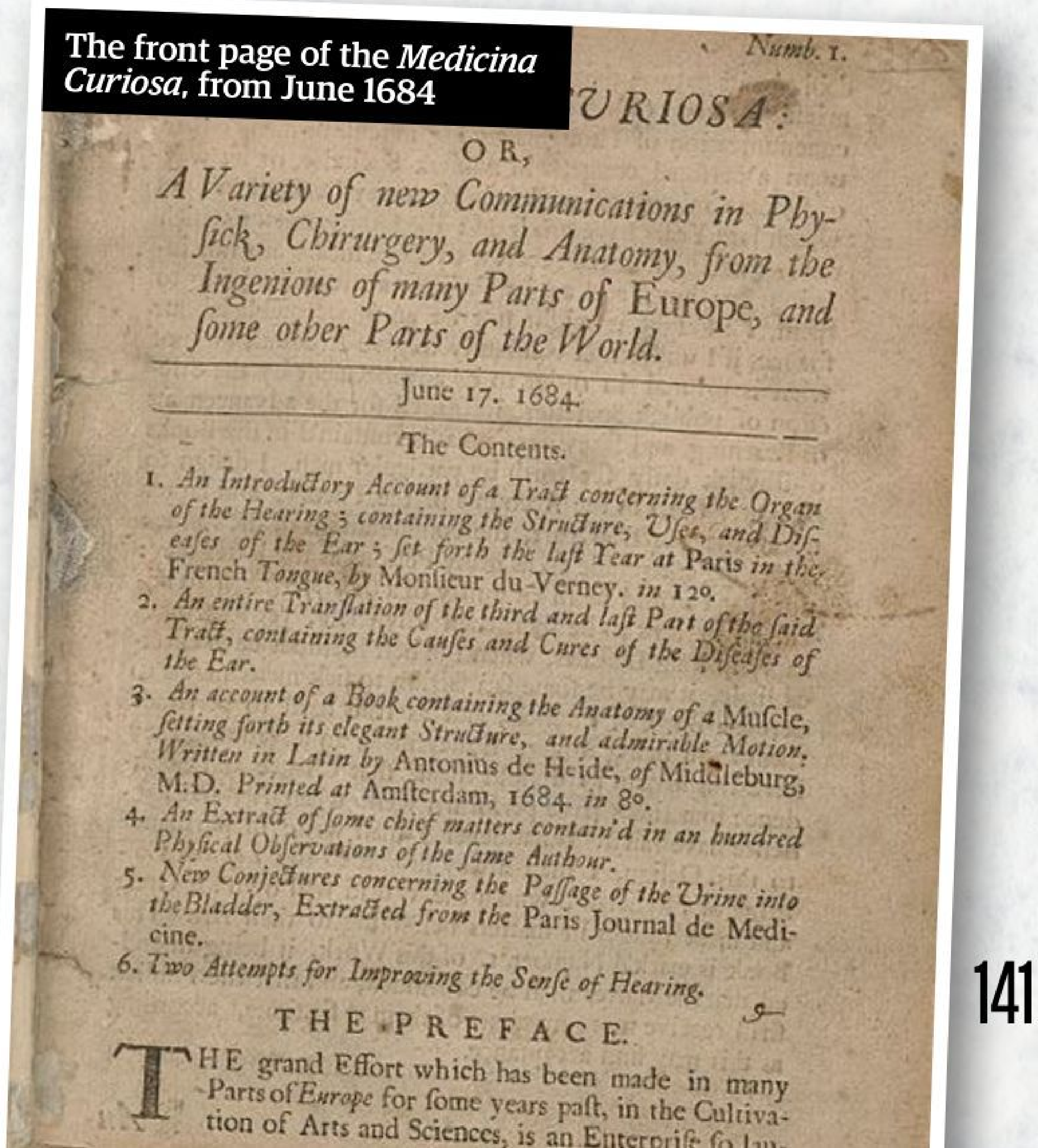
As the number of university-trained physicians increased during the 17th century, alongside the movement from Latin to English-language medical works, the field of medical journalism emerged

Medicina Curiosa, the first English general medical journal, was published in 1684. Although there were previous publications that discussed medicine, the *Medicina Curiosa* was the first dedicated solely to it. It was originally published by Thomas Basset, a bookseller who specialised in law books, but it only lasted for two issues before it ceased to exist.

During the 18th century, the first peer-reviewed medical journals were published. In 1731, the journal *Medical Essays And Observations* was published in Edinburgh while in the United States, the first published journal was *The Medical Repository* in 1797.

Thomas Wakley founded one of the world's oldest general medical journals, *The Lancet*, in 1823. He was a surgeon and unsurprisingly chose to name it after a surgical instrument, the 'lancet.' Wakley created the journal to report on hospital lectures and important medical cases. By 1830, *The Lancet* had a circulation of around 4,000 copies and played an important role in medical and hospital reform in Britain. *The Lancet* continues to be published weekly to this very day and has even branched out into creating a series of speciality journals, for example focusing on areas such as neurology and paediatrics.

Today, hundreds of medical journals are published around the world, ranging from the broad, general publications that emerged from the late 17th to 18th centuries to the more speciality-focused ones that were first established during the 20th century.



The front page of the *Medicina Curiosa*, from June 1684

Numb. 1.

URIOSA:

OR,

A Variety of new Communications in Phyſick, Chirurgery, and Anatomy, from the Ingenious of many Parts of Europe, *and ſome other Parts of the World.*

June 17. 1684.

The Contents.

1. *An Introductory Account of a Tract concerning the Organ of the Hearing; containing the Structure, Uſes, and Diſeaſes of the Ear; ſet forth the laſt Year at* Paris *in the* French *Tongue, by* Monſieur du-Verney. *in* 12º.
2. *An entire Tranſlation of the third and laſt Part of the ſaid Tract, containing the Cauſes and Cures of the Diſeaſes of the Ear.*
3. *An account of a Book containing the Anatomy of a* Muſcle, *ſetting forth its elegant Structure, and admirable Motion. Written in Latin by* Antonius de Heide, *of* Middleburg, M.D. *Printed at* Amſterdam, 1684. *in* 8º.
4. *An Extract of ſome chief matters contain'd in an hundred Phyſical Obſervations of the ſame Authour.*
5. *New Conjectures concerning the Paſſage of the Urine into the Bladder, Extracted from the* Paris Journal de Medicine.
6. *Two Attempts for Improving the Senſe of Hearing.*

THE PREFACE.

THE grand Effort which has been made in many Parts of *Europe* for ſome years paſt, in the Cultivation of Arts and Sciences, is an Enterpri

IV NEEDLE/ HYPODERMIC NEEDLE

Sir Christopher Wren England, 1656

Used widely today, the hypodermic needle offers the quickest way to administer vital medications to the body

The hypodermic needle is used for many things, including injecting intravenous drugs and solutions directly to the veins

The first recorded experiment of the hypodermic needle was by Sir Christopher Wren, who used it to perform intravenous injections on dogs. In the 1660s, experiments were also conducted on humans but they proved unsuccessful, and were subsequently abandoned.

It wasn't until the 19th century that the use of hypodermic needles was picked up and used more successfully in conjunction with syringes to administer medicine to the body. Dr Thomas Latta used them to deliver saline solutions, something he pioneered, during the chlorea epidemic in Britain, 1831. Also, Dr Alexander Wood's successful work with the needle and syringes popularised the method as an acceptable medical technique.

By the 1920s, the needle proved useful when it came to delivering insulin to people who were suffering with diabetes. In the 1950s, the disposable hypodermic needle was created after the understanding of, and issues with, cross-contamination became widely known - also a concern during the 1980s with the HIV epidemic.

Hypodermic needles are used every day in modern medicine, whether it is to administer liquid drugs and solutions to the veins or to take liquid samples, such as blood, for medical tests. They can be used by many medical professionals but can also be used by patients, particularly those with Type 1 diabetes who are required to self-inject insulin every day.

William TG Morton performing the first public demonstration of inhaled ether as a surgical anaesthesia

SURGERY UNDER ANAESTHESIA

Crawford W Long United States, 1842

With the discovery of anaesthesia, surgery could be safely performed without the patient suffering from pain and distress

Sedatives such as alcohol and opium were used for centuries to inhibit pain, but by the 19th century new substances were being explored. For example, Humphry Davy experimented with nitrous oxide in 1799 and discussed the capability of it providing pain relief during surgery.

Not everybody involved in the development of anaesthesia was celebrated. During the 1820s, Henry Hill Hickman was experimenting on animals using carbon dioxide as anaesthesia, but his work was ridiculed at the time. Meanwhile Crawford W Long was interested in the use of diethyl ether and in 1842, administered it by inhalation to a patient in order to remove a tumour from their neck. He continued to use ether as a general anaesthetic but failed to publish his work until 1849 - for this reason he has been rather forgotten in the history of anaesthesia.

It is William TG Morton who appears to be celebrated most for his work with general anaesthesia. In 1846, he performed the first public demonstration of diethyl ether as a general anaesthetic for surgery at the Massachusetts General Hospital. It was a success and news of Morton's work quickly spread, which subsequently meant that he was seen as the pioneer over Long.

By 1847, chloroform had emerged as a safe anaesthesia and it was even administered to Queen Victoria during childbirth for her youngest two children. Throughout the 20th century, a series of intravenous and inhalational anaesthetics were developed along with intubation, a different way to administer them.

Employees waiting in line to receive their vaccination for influenza at the workplace, *The Denver Post*, in 1957

VACCINATION PROGRAMME

Edward Jenner England, 1796

Vaccination programmes have helped to eradicate some of the world's most feared diseases but controversy surrounding vaccines still remains

Although Edward Jenner did not actually invent the first vaccination programme, he did nonetheless create the first vaccine for smallpox – without him, there would be no such thing as immunisation. As vaccinations proved effective, a number of vaccination programmes were being rolled out across the United Kingdom and other parts of the world during the 19th century, largely focused on the vaccination of children.

During the 1920s, vaccinations for tuberculosis, diphtheria, tetanus and whooping cough became widely available for the first time, resulting in a dramatic fall in the number of deaths from these diseases. In the 1950s, the polio vaccine was introduced and thanks to vaccination programmes, it is close to being completely eradicated.

In 1974, the World Health organisation established the Expanded Programme on Immunization (EPI) with the aim to make vaccines available to all children throughout the world – a decade later, the WHO also created a standardised vaccination schedule for certain vaccines. By 1980, it announced that smallpox – one of the world's deadliest diseases – had been completely eradicated.

New vaccination programmes are still being introduced today, for example the HPV vaccination to protect teenage girls from cervical cancer. However, despite the success of such programmes, vaccinations continue to provoke controversy. When Jenner first unveiled his vaccine, there were those who opposed it because it involved animal material. Over the last century, concerns have included issues such as allergic reactions and the perception that vaccines can cause serious illness or even autism, despite no link being found between vaccines and the latter.

Lind is believed to have conducted the first modern controlled clinical trial

CLINICAL TRIAL

James Lind On board HMS Salisbury, 1747

It is thanks to clinical trials that we can determine new, safe and effective medical strategies, treatments and devices to help treat illnesses

With scurvy decimating the British sailors at sea, Lind conducted a controlled trial to see if adding acidity to their diets would improve their health. He started his experiment on board a ship after it had been at sea for two months, with the men already suffering with scurvy. Lind picked 12 sailors and divided them into pairs to create six test groups.

Each group maintained the same diet but Lind introduced a different acidic supplement to each: the first group received a quart of cider daily, the second took 25 drips of vitriol elixir, the third had six spoonfuls of vinegar, the fourth drank half a pint of seawater, the fifth was given two oranges and a lemon and finally, the sixth had to eat a spicy paste washed down with a glass of barley water.

The fifth group were forced to stop the trial early because they had run out of fruit. However, they had all almost recovered from their illness, while group one was the only other pair to show signs of improvement. Lind tried his best to keep potential confounding factors consistent, right down to picking 12 men who were as similar as possible – because of this attention to detail, it is considered to be one of the first clinical trials ever performed.

Other physicians between the 18th and 19th centuries performed further clinical trials. By the 20th century, the methodology for the proper design of experiments was pioneered by figures such as Ronald A Fisher and Austin Bradford Hill.

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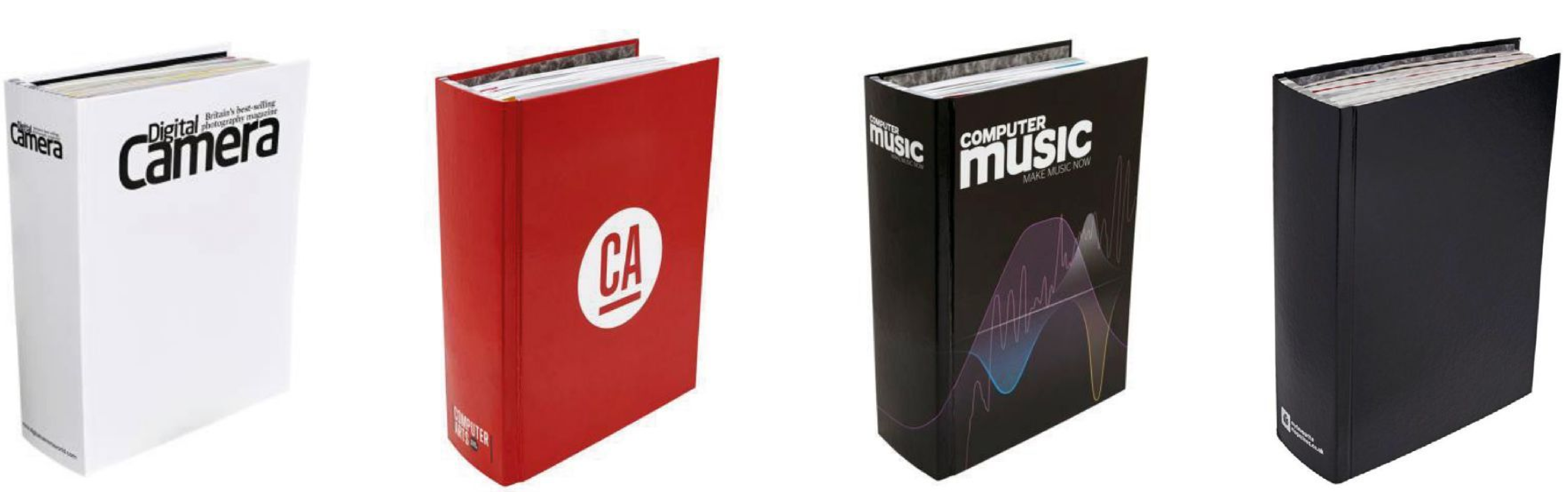

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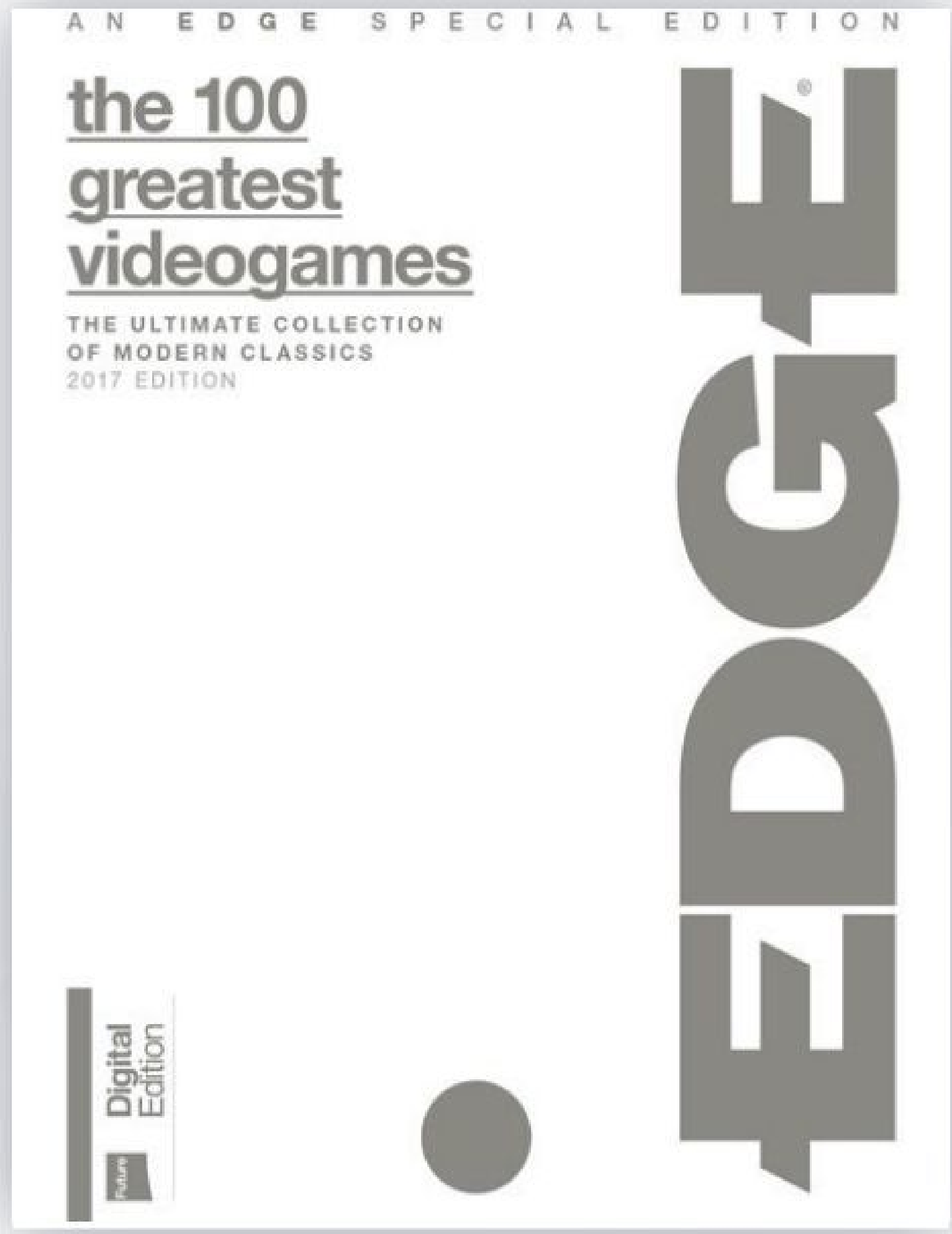

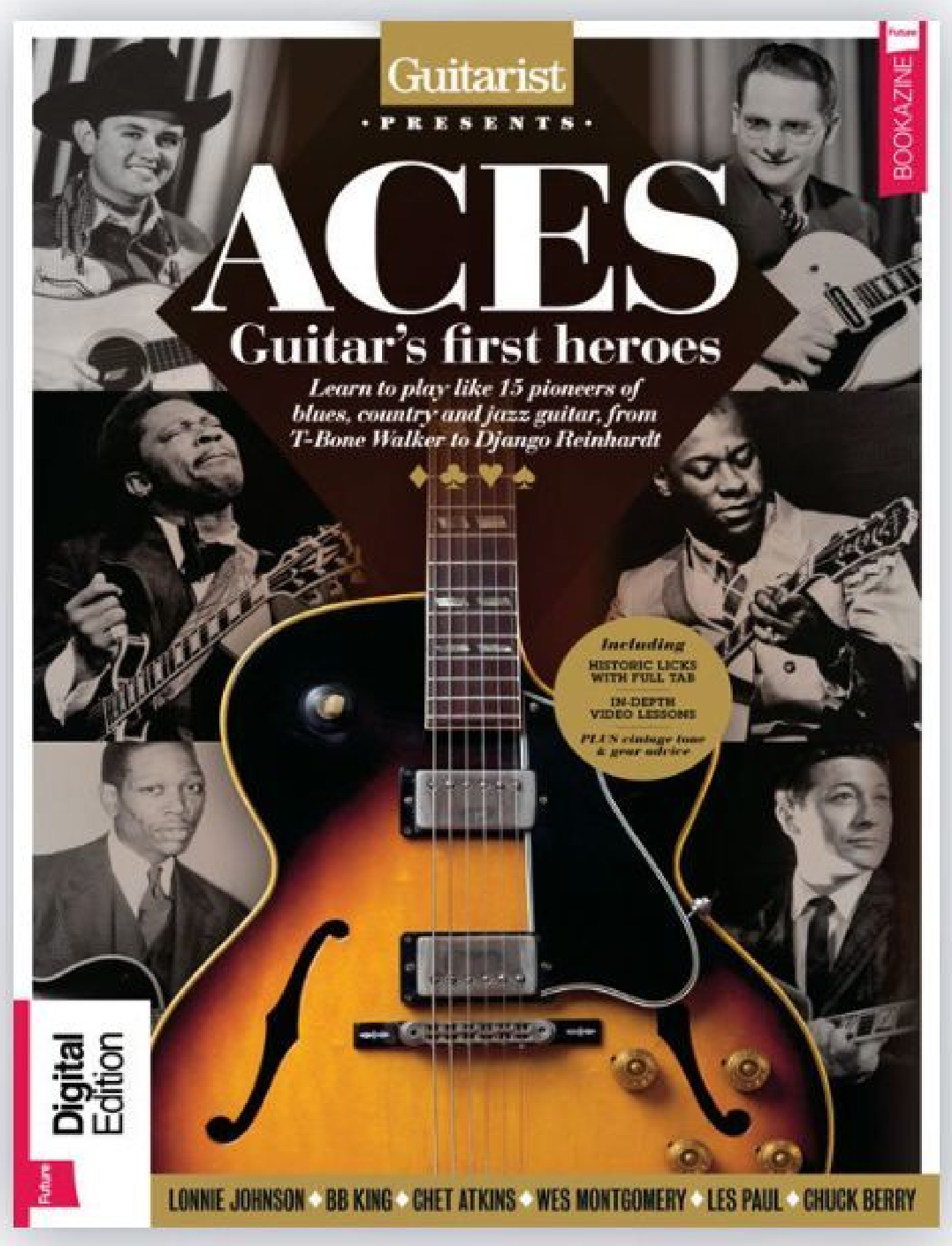

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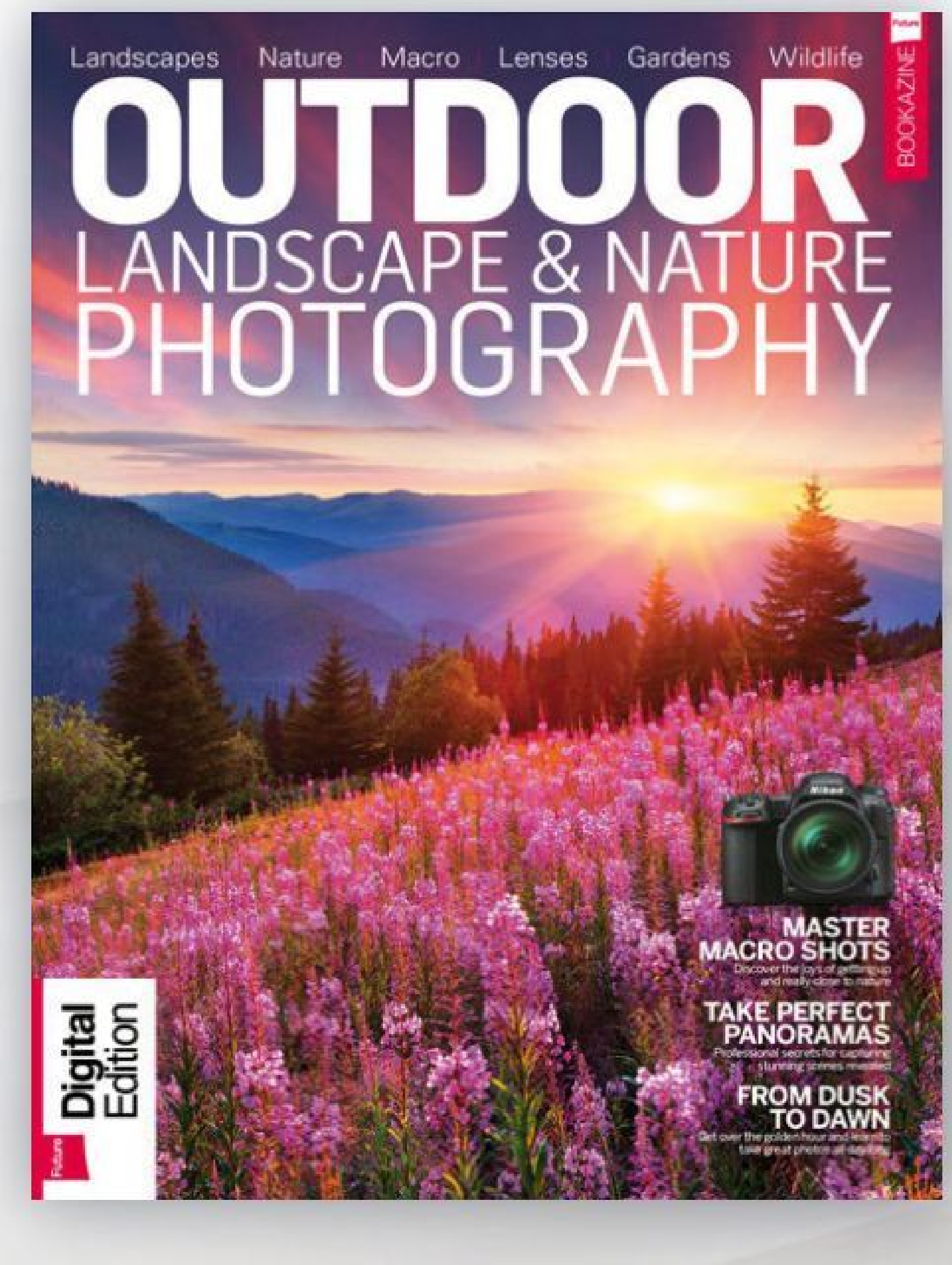

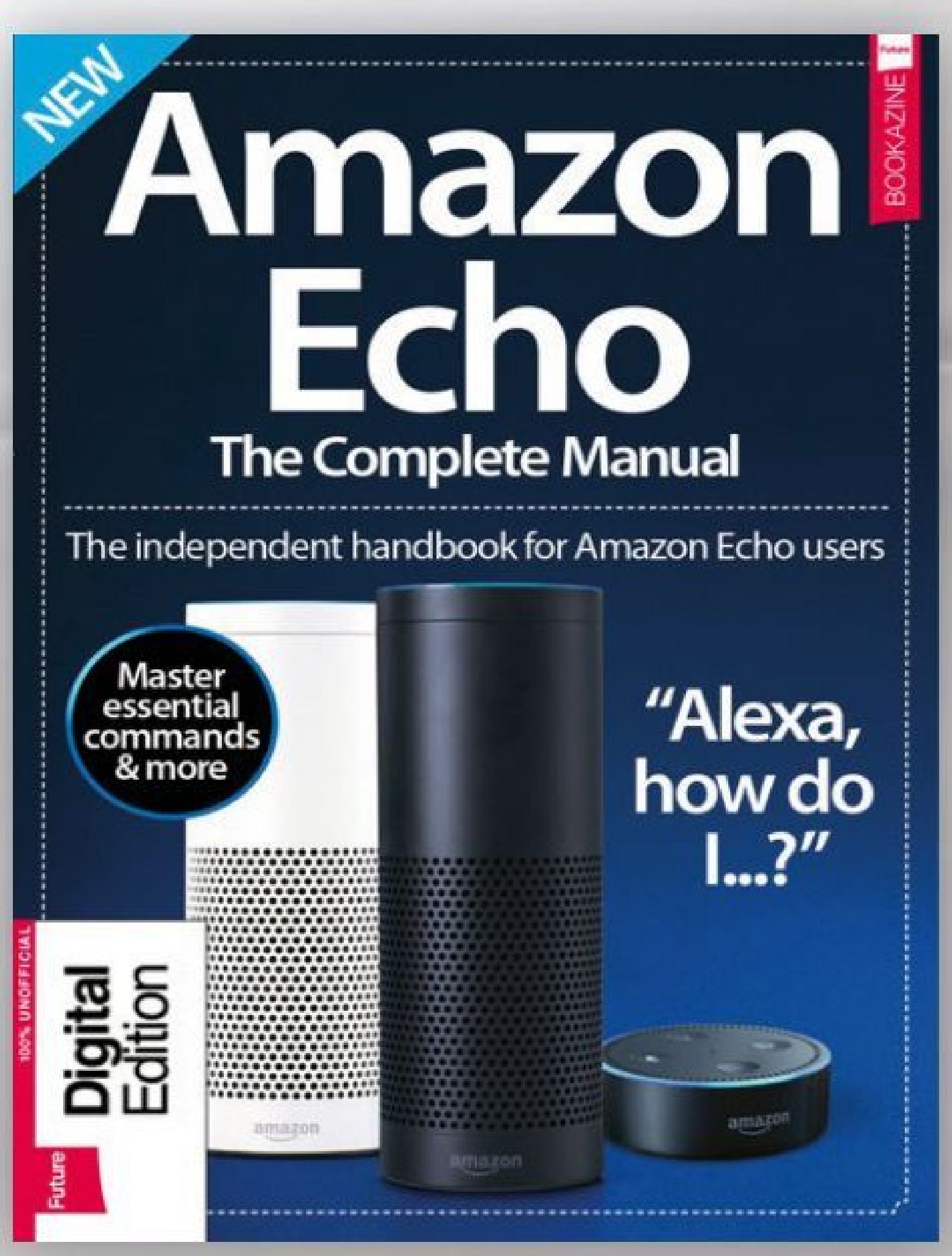

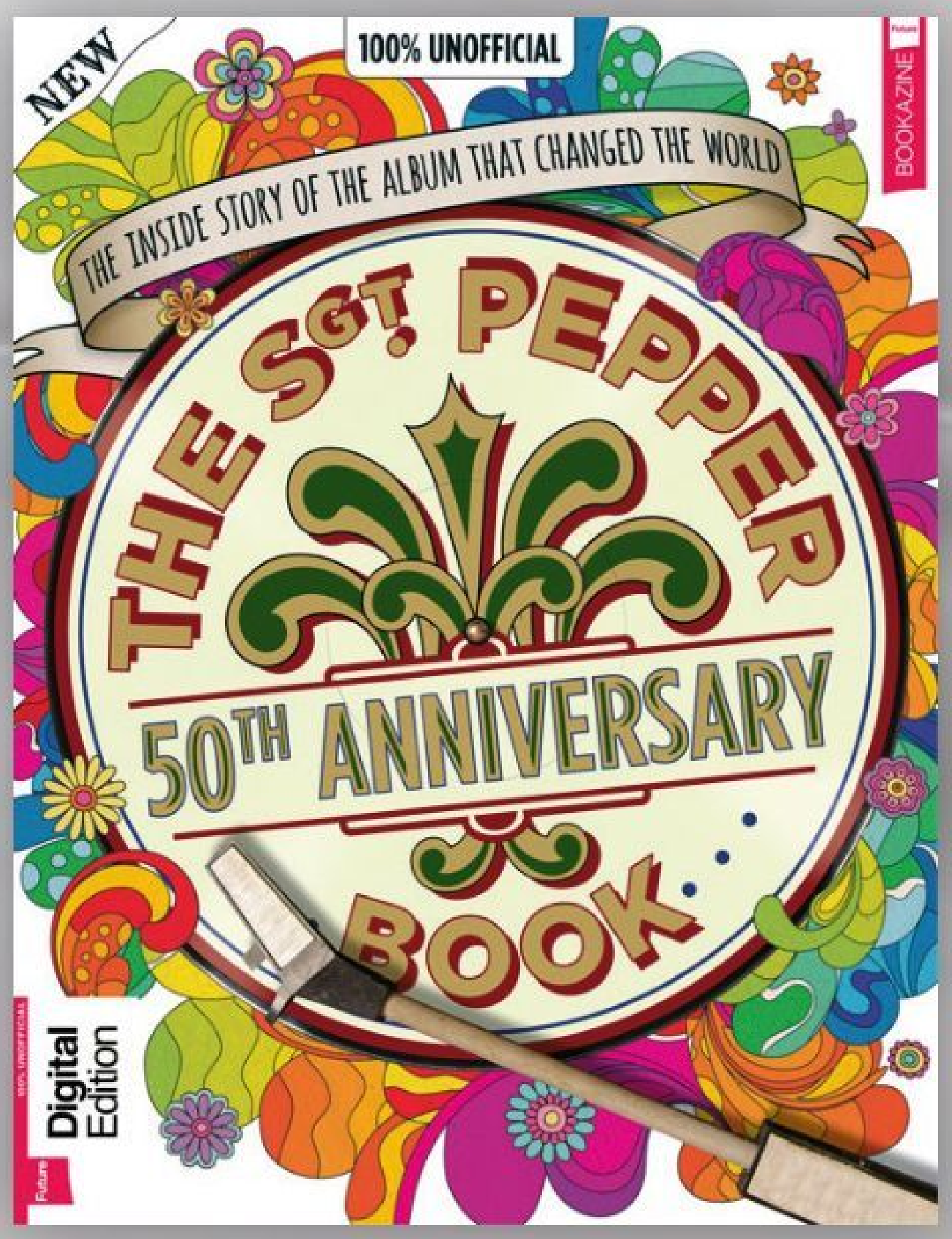
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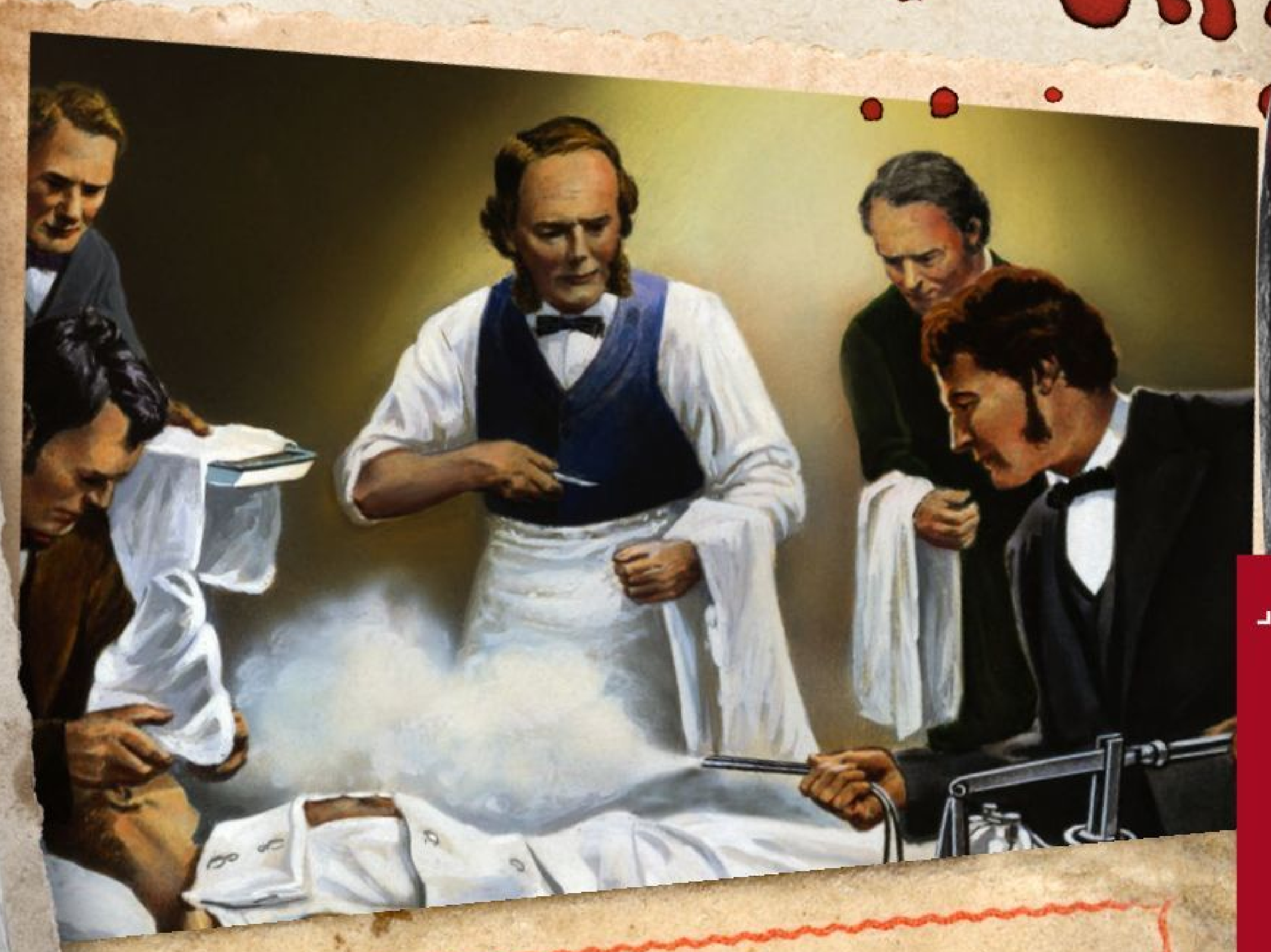

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